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ABSTRACT

This curriculum guide for grades K-6 was prepared to assist teachers and students in learning about the metric system. An introductory section presents a brief history of the metric system and the rationale for introducing it into the schools. Instructional objectives and suggested learning activities are presented for each grade level. The activities vary in format, and sometimes include objectives and followup as well as materials required and procedures. Sample activities include using measuring wheels; weighing snow; using scales, bar graphs, and the Celsius thermometer; and constructing a quadrate out of doors. A short section illustrates how the metric system can be taught at the junior and senior high levels. Background and reference materials for the teacher in the intermediate grades are provided and include tables, charts, and conversion data. A list of references used in preparing the guide is appended. (RG)

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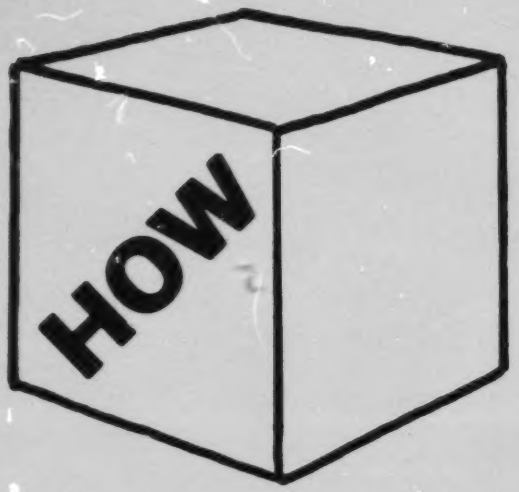
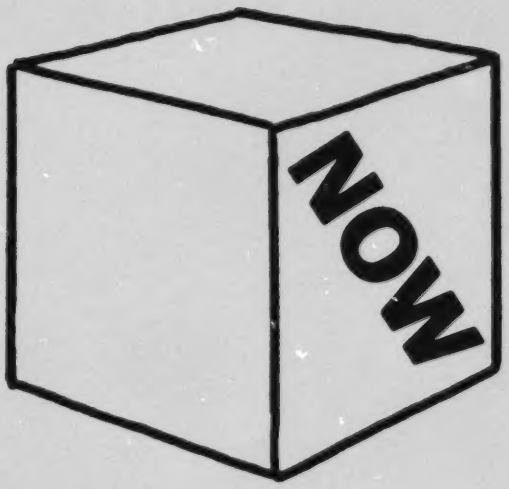


TO TEACH METRIC



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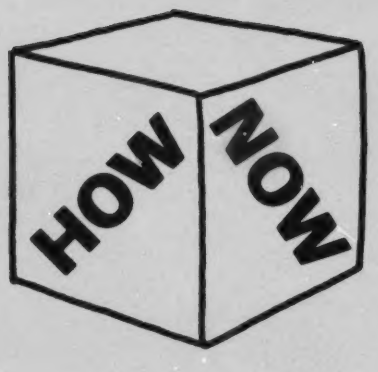

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FOREWORD

The Administration and the School Committee of the Worcester Public Schools appreciate the time and effort given by the Metric Committee in developing this Metric Report.

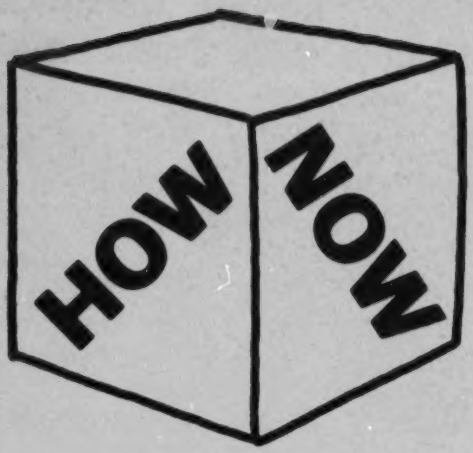
At the close of 1972, the United States Senate unanimously voted to convert to the metric system under a ten year plan. Concurrence by the House is expected sometime in 1973. At any rate, the United States, the last stronghold of the English or Customary System, is being engulfed by the international tide of metrication. Many industries have begun or concluded the changeover out of necessity. Legislation, or the lack of it, is merely academic. It is thus, with a great deal of forethought, that the Worcester Public Schools have embarked on such a study.

This curriculum guide for grades K-6 will assist pupils, teachers and parents in learning about the "new" measuring system and effect a smoother transfer from the present system of weights and measures.

"How long is it?" – "How much does it weigh?" – "How fast is it going?" "What is its volume?" are common questions in the school environment.

We urge staff members using this curriculum guide to use it as a framework of their teaching. I am sure that members of the Metric Committee would appreciate any changes or suggestions which would expand on opportunities for pupils as presented by this outline.

John J. Connor
Superintendent



TO TEACH METRIC

Weights and Measures may be ranked among the necessaries of life to every individual of human society. They enter into the economical arrangements and daily concerns of every family. They are necessary to every occupation of human industry; to the distribution and security of every species of property; to every transaction of trade and commerce; to the labors of the husbandman; to the ingenuity of the artificer; to the studies of the philosopher; to the researchers of the antiquarian; to the navigation of the mariner, and the marches of the soldier; to all the exchanges of peace, and all the operations of war.

The knowledge of them, as in established use is among the first elements of education, and is often learned by those who learn nothing else, not even to read and write. This knowledge is rivited in the memory by the habitual application of it to the employments of man throughout life.

John Quincy Adams
1821

OPENING STATEMENT

It was the wish of the Metric Committee that every teacher receive a copy of this notebook. It was felt that the information herein would help even those who are not directly involved in the teaching of measurement to adjust to the international onslaught of the metric system. Much of the work for primary and intermediate grades can easily be adapted to secondary use.

The technical name of the metric system is System Internationale d'Unites or its English equivalent, International System of Units (SI).

The fact that secondary courses are already metrically oriented accounts for the short section for junior and senior high.

It is the hope of the Metric Committee that the following pages will be helpful and usable. As more material becomes available, it will be passed on to you and easily included in this notebook.

The Committee worked long and hard and wishes to give special thanks to Dr. Arthur Sullivan who initiated the project and who gave unselfishly of his time and talent.

The Metric Committee

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RATIONALE

Metrication is upon us! Some sectors have been metric for years, while others are going in that direction due to their commercial relationships with other nations. The United States remains the only large industrial nation which has not officially adopted the metric system. However, before the end of the 1972 Congressional Session the Senate voted to convert to the metric system over a ten year period. It is the consensus that the House will do so in the near future. In any event, the metric system is here to stay! According to many experts, the United States will not survive economically unless it metricates.

The Metric Committee was formed to find and put into operation a means of educating the school population in the metric system. To this end, we have agreed that the end product of our labor will be an easily understood curriculum guide for kindergarten through grade six. The guide will contain easily understood information for the teacher, suggested materials, teaching hints, behavioral objectives, and recommended materials for each room and/or building.

The committee also agrees that, especially at the primary level, it will be less confusing for the teacher and the student, if the metric and the customary systems were taught as separate systems with no conversions from one to the other.

The Metric Committee

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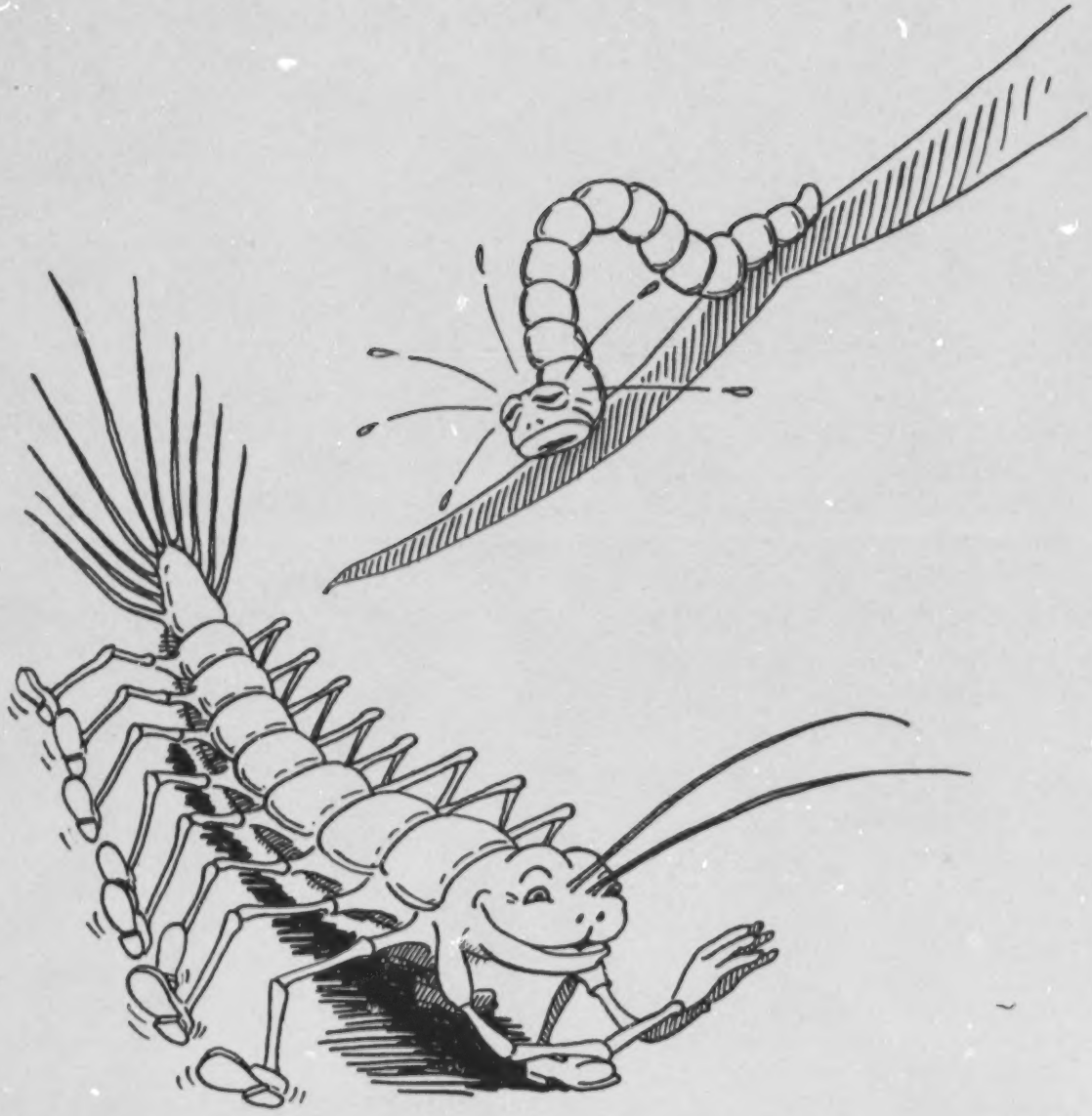

A centipede tap-danced with glee
While an inch worm cried, "Ah, woe is me!
If all of this rhet'ric
Drives the USA metric,
There's surely no future for ME!"

A Thumb-Nail Sketch of Metric History

One of Washington's first requests was that Congress establish a uniform set of weights and measures for our new country as "directed by our Constitution". A decimal coinage system was established to replace pounds and shillings and Thomas Jefferson was appointed to work on linear measurement. After six years, Jefferson's efforts were set aside.

In 1795 France defined the meter and she became the first world power to "think metric". She urged other countries to join her. England replied, "We have a standard system that works". Scientific Frenchmen continued to seek support from other nations. In John Quincy Adams they found an advocate for world uniformity in weights and measures.

In his term Adams established the first such Congressional study and he stated that all nations should adopt a standard system at the same time. But, it wasn't until 1865, acting upon an earlier proposal of Abraham Lincoln's that Congress legalized the metric units of length and weight and permitted their use along with English yards and pounds. In 1893 The National Bureau of Standards began using the metric system as their basis for making decisions.

Since 1893, countless efforts have been made to make the United States a totally metric country. Until 1965 we had England and Canada as non-metric allies. Now we stand alone as the only major world power not in the process of converting.

Aware parents and citizens recognize that children use chemistry sets that measure in grams, that children have skiis measured in centimeters, and that children watch television coverage of metrically measured sporting events.

Textbook writers and other educators recognize that even first and second graders can add centimeters as easily as they can add sets of inches or apples. Many of these educators advocate immediate introduction of activities using the base-ten metric ruler along with our accustomed twelve-inch ruler. All authorities stress immediate teacher education.

Some Important Dates
In The Evolution of The Metric System

1670 Gabriel Moulton, a French vicar, founded a base-ten system for measuring. He based his unit on a fraction of the earth's circumference.

1789 President Washington commissioned Jefferson to establish a practical standard set of measurements.

1795 France adopted a decimal system for linear measurement defining the meter as one ten-millionth of the distance from the North Pole to the equator, along the meridian passing near Dunkirk and Paris.

International Conference set up in Paris to demonstrate their practical system.

1799 End of the French Revolution and metric system of measurement in partial use. Common people to "folk" systems.

1812 Napoleon Bonaparte allowed working classes to use their household units, but metric system was encouraged.

1816 President Madison reminded Congress that the lack of uniform standards for weights and measures "constitutes an important piece of unfinished business".

1821 President Adams, in his report on Weights and Measures, stressed the need for a universal system.

1832 To aid customs officials, the U. S. adopted some English improved standards.

1837 France returned to totally metric system.

1850 Metric system began to spread. Adopted by Netherlands, Greece, Spain, and parts of Italy.

1866 Kasson Committee introduced some favorable bills to Congress. Metric weights and measures legalized. Official conversion charts written. Metric scales distributed to post offices handling foreign mail. Each state given official sets of metric measures.

1873 Founding of the American Metrological Society to promote the metric system and to outline strategy for teaching the system in schools.

1875 *The Treaty of the Meter* signed in Paris after 5 years of meetings. United States participated. National Educators Association participated. A world repository set up to house exact models of the units. (The International Bureau of Weights and Measures near Paris).

1876 Founding of American Metric Bureau (Boston) especially for promoting the knowledge of metric system through educational institutions.

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(Continued on Page 7)

1877	Another series of demands began pressing Congress to adopt the metric system.
1879	Founding of an organization to oppose the metric system and to uphold the English system (The International Institute for Preserving and Perfecting Weights and Measures).
1899	An attempt to totally convert to the metric system failed by narrow margin. The Hurley Bill stressed the simplicity of the metric plan.
1902 to end of War I	Organized **opposition** led by a prominent engineer, a prominent textile magazine editor, and the American Institute of Weights and Measures.
	Organized **support** led by the American Metric Association formed with headquarters in New York. The World Trade Club opened in San Francisco and also gave support.
Post War	A 30 year lull in which 40 bills were introduced but only two hearings held (Depression years).
War II	Not much action during the war. But in post-war years, Uncle Sam dominated the world's production and its exchange of goods. No need for change.
Sput-nik	Citizens returned to science classes and laboratories. U. S. Army weapons were built to metric specifications. The United States and England agreed on metric equivalents for their inch-pound units.
1960	A General Conference of Weights and Measures. The United States took part. Differences between national measurement units were cleared. The result was the International Metric System. Technical circles refer to this authority as "S I" (Systeme International d'Unites). This body is – and will continue to be – a clearing house for questions regarding measurement units.
1965	Britain voted to convert to metric system to ease and encourage European trade. Canada followed leaving the U. S. as the only non-converted large nation.
1972	The U. S. Senate unanimously voted to convert to metric under a ten-year plan.
	NEA recommended that education begin immediately in our schools to prepare children for the future.

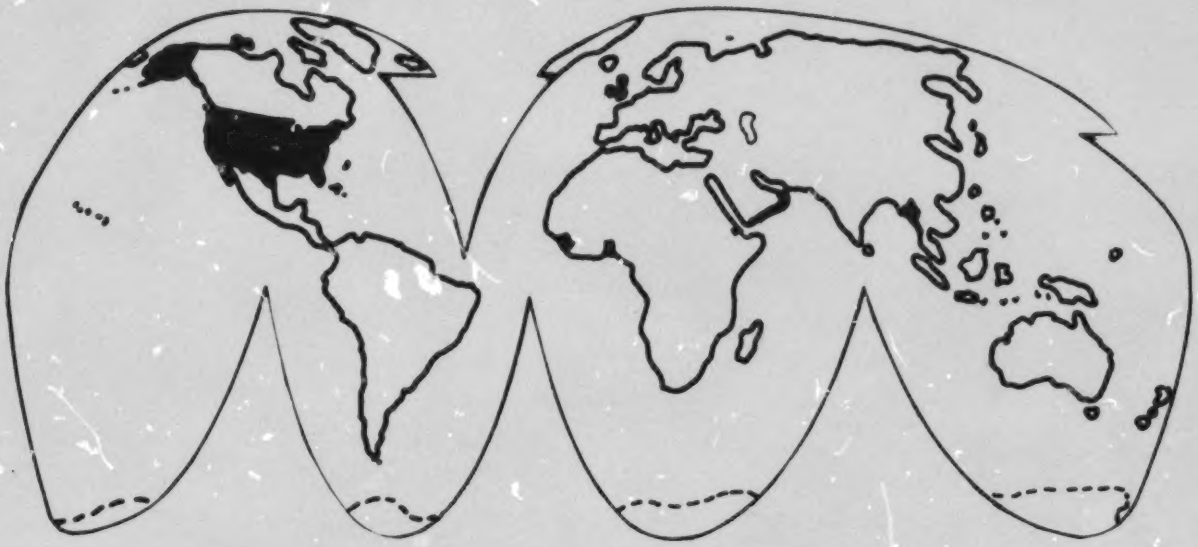
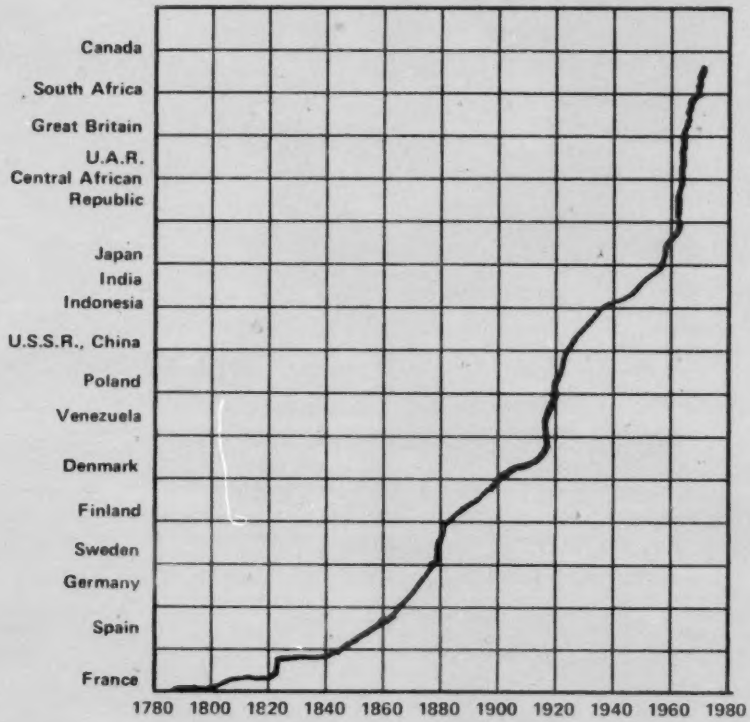


Fig. 1 Nonmetric countries. The countries shown shaded are those which are neither metric nor committed to metric, as per [1]. These include Barbados, Burma, Gambia, Ghana, Jamaica, Liberia, Muscat and Oman, Nauru, Sierra Leone, Southern Yemen, Tonga, Trinidad, and the United States.

Fig. 2 Growth of metric usage by countries (from a talk "The Practical Dilemma of Paper Sizes," by A.U. Dunn, Department of Defense Production, Ottawa, Canada).



(from *Mechanical Engineering*, Mar. '73)

How Does NEA Feel About Teaching Metric in Our Schools?

From *NEA Reporter*, May 1973, p. 7

C-16 CONVERSION TO THE METRIC SYSTEM

The National Education Association believes that a carefully planned effort to convert to the metric system is essential to the future of American industrial and technological development and to the evolution of effective world communication. It supports federal legislation that would facilitate such a conversion.

The Association declares that teachers of all grades should teach the metric system as the preferred system of weights and measures of the United States beginning in 1973-4, should teach the metric system with greater emphasis to assure, as a National goal, the orderly transition to the metric system as a primary system by 1980.

From p. 95 of *Education (A Metric Study)*, Nat'l. Bureau of Standards

New teaching aids will be needed however, as illustrated by the following list of basic items:

1. meter sticks and metric rulers
2. cubes, squares, strips, and rods calibrated in metric units
3. the meter board, 1cm thick and a meter long and a decimeter wide. This board can be divided into ten squares showing a 100 cm grid. These ten squares when stacked become a cubic decimeter.
4. scales and balances calibrated in grams and kilograms
5. centimeter grid paper
6. maps in metric scale, showing distances and areas in metric units
7. cylinders and beakers graduated in metric terms
8. Celsius thermometers

Likewise there are a few basic principles in methodology which experience and logic would seem to dictate, such as:

1. The instruction in metric measurement will need to begin when the child is first introduced to the concept of measuring an object and should continue to be taught, with growing levels of understanding and application in every grade.
2. Linear units of measure, the easiest to comprehend and apply will be taught first.
3. Instruction will need to be restricted to a single system using metric units only and without the old units "tagging along".
4. Teachers will emphasize first the most-used prefixes, introducing the less-used ones (such as deci – and deca–) after the basic ones are learned.
5. Relatively greater stress will be laid on the use of the decimals and less on fractions.
6. Much practice will be needed in **using** metric standards and **estimating** in terms of metric units.

SOME GROUPS THAT PARTICIPATED IN THE
METRIC STUDY

MEASURING

We'll measure today
With pencils and blocks,
Use mittens and fingers
And ribbons and socks.

We'll find out how long
The room is in toes,
Discover if snowflakes
Are long as our nose.

We'll measure our desks,
The windows and chairs,
And see if umbrellas
Are taller than chairs.

And then we will say
When the measuring's done,
We know about sizes
And knowing's such fun!

June Gould

KINDERGARTEN
OBJECTIVES & VOCABULARY

are not going to be any different when we begin to introduce metric measurement in the elementary grades.

The very young child first has to learn to compare the sizes of the familiar objects around him. He has to learn to use the words that tell about sizes. And as the above poem suggests, he needs to have many and frequent experiences measuring with familiar objects.

Measuring with precise units like the inch and centimeter come later when he has learned more about numerical values and matching.

Kindergarten vocabulary

long, longer, longest
short, shorter, shortest
tall, taller, tallest
wide, wider, widest
large, larger, largest
small, smaller, smallest
high, higher, highest
low, lower, lowest
etc.

Curriculum Content For Primary Grades

Although the following objectives are given by grades it is expected that teachers will adjust the tasks according to the abilities and experiences of the children.

As the child's ability to read and measure develops, he may make some approximate conversions as he scans the breakfast cereal box, and as he reads jelly-jar labels. In any case, all child experts agree that conversion and precise accuracy are not goals to be stressed in primary classes. It IS important that primary children have frequent and varied experiences in measuring.

It's more essential that the primary child actually pours quarts into liters and that he weighs ounces and grams, than it is for him to memorize the precise number value representing the relationship between the units.

Grade One

At the end of Grade I the child will be able to:

- order objects relative to size
- describe objects relative to size
- state whether objects shown him would be measured with a meter or a liter
- identify $.01 and $.10 in terms of tens

Grade Two

At the end of Grade II the child will be able to:

- measure objects to the nearest centimeter
- identify a liter, a milliliter, a centiliter, a deciliter
- identify our basic coins and the dollar bill
- associate measuring with number lines
- add and subtract using money
- add and subtract using linear and capacity units

Grade Three

At the end of Grade 3 the child will be able to:

- maintain and extend earlier ideas
- identify freezing and boiling points on a Celsius thermometer and be able to read degrees of temperature
- identify a gram, a milligram, centigram, decigram, kilogram
- use the term 'kilometer' as a term of reference

Metric Vocabulary

Grade I

decimal, centimeter, liter, meter, dime, cent, dollar, centipede, half

Grade 2

Celsius, centigrade, degree, deciliter, milliliter, boiling, freezing, half (and other simple parts of a whole)

Grade 3

gram (with prefixes up to kilo) terms mile and kilometer

LINEAR MEASURE: The Centimeter

GRADE ONE

(Introduce when the children have mastered number sequence to 100 and when they begin to organize addition and subtraction in a relationship)

Rationale

To develop understanding of the centimeter and how to measure with a ruler and how to record centimeters. To provide experiences in comparing lengths and heights.

Terms to be used

measure, ruler, centimeter, centimeters, long, longer, longest, short, shorter, shortest

Materials

Rulers on which centimeters are marked

Procedure

- Identify ruler. Talk about its use.
- Have the children decide how to use the ruler. Be sure they are aware of placement rules.
- Explain that the line by the 1 is one centimeter away from the end of the ruler, and the line by the 2 is two centimeters from the end, etc.
- Have children take turns telling about numbers.
- Hold up two pencils (eg.) Ask which is longer, shorter?
- Measure to see how long each is. Repeat with similar objects.
- Draw lines on board. Have volunteers measure and tell lengths in centimeters.
- Have a worksheet on measuring centimeters, longer, shorter etc.

Follow-up Lesson

- Have children measure lengths of books, toys, blocks, Write numerals. Tell what is longer, shorter, etc.
- Have a worksheet of pictures.

Name _____ Date _____

(Children like to think of being part of a world-wide effort. A small sketch of children of other countries using metric measurement is effective in promoting the scope of thinking).

Marie's Metric Ruler

Marie of France says, "You use a yard stick. In my country, everyone measures lines with a meter stick.

It is easy to measure our way because we think about sets of tens."

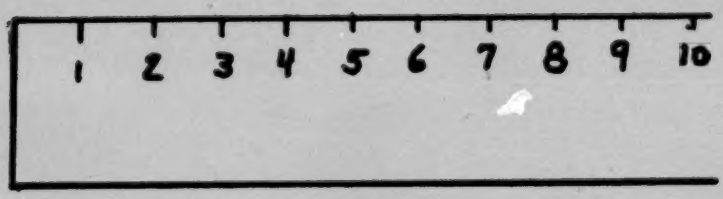
10 cm
20 cm
30 cm
40 cm
____
cm

10 cm
+ 10 cm
____
cm

10 cm
10 cm
10 cm
+ 10 cm
____
cm

5 cm
2 cm
+ 3 cm
____
cm

This is part of Marie's metric stick. Ten parts this size make her meter.



(Coioring sheets with appropriate pictures and captions are an effective way to reinforce metric words and concepts)

Draw some trees and other things in this winter scene.

"My new skiis are measured in centimeters".

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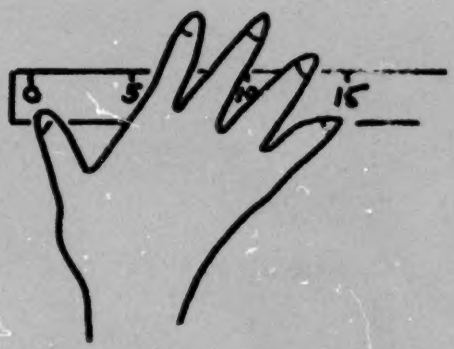
"The hand span of the average second grader is 15 cm", reports a second grade teacher.

Measuring hand spans introduces an activity which can be graphed simply.



Rational

Estimating is fun for children. And when their two hands together are about equal to our convenient ruler (30cm) the children always have a handy measuring device with them.

Terms to be used

measure, estimate, centimeters, span, graph, graph key, graph title, data

Materials

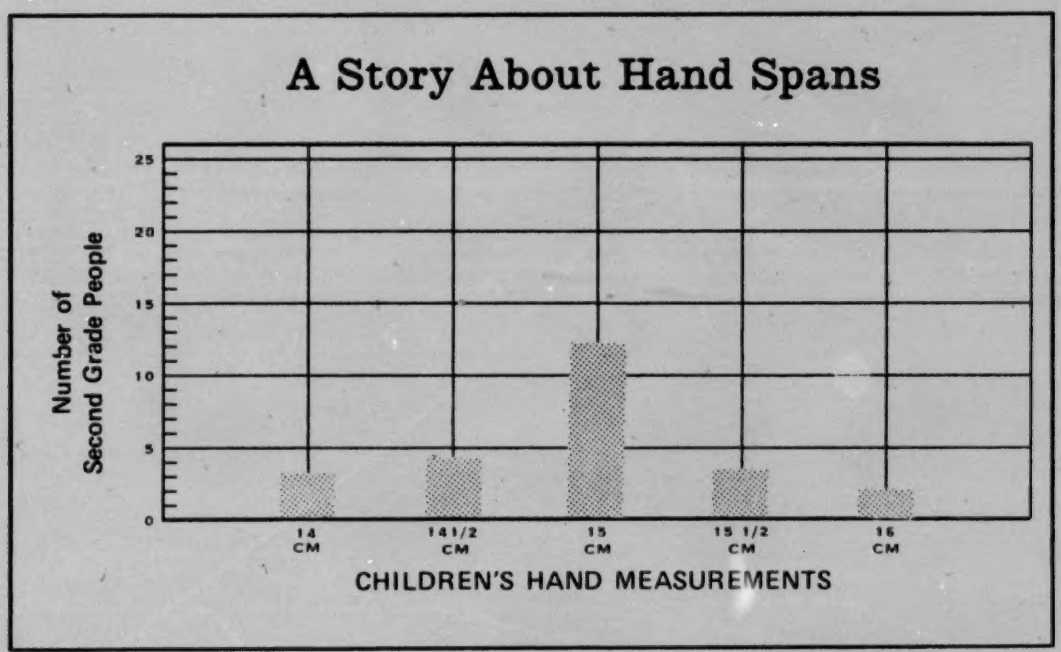
paper for each child to trace his hand and record his measurement, centimeter rulers, large experience chart graph to record class measurements

Procedure

Ask if anyone knows that 'hand-span' means. Discuss hand sizes of class members, Have each child trace his hand with a pencil and record his measurement. One the chalkboard, make lists of the different sets that are possible. Record the data and then ask the children to interpret their graph story.

Follow-up activity

Have children use their two hands to estimate lengths of desks, books, etc



Money Is A Useful Aid

In Your Classroom Measuring Center

Our coins are a good item to use in a balance because they are carefully weighed at the mint. Eg. A nickel weighs 5 grams and is 2 cm in diameter. Let the children compare sets of our various coins.

Activity

Have the class find several sets of small objects that balance a nickel.

Rational

The children enjoy this task. And they make some meaningful discoveries about everyday objects. If gram scales are available to check their findings, they are surprised to learn about the weight of tares[1] as light as a plastic baggie. Then they take the weight of the tare into consideration when assembling other sets.

Materials

balance scale (can be improvised)
several nickels, some other coins for study
small sets of tiny objects (paper clips, tacks, beads, elastic bands, buttons, etc)
some suitable tares (plastic pill containers, baggies)
egg carton cups to separate 5 gram sets

Objectives

At the end of this activity the children will be able:
to state that all U. S. coins of equal value have the same weight
to assemble sets of objects that weigh about 5 grams
to demonstrate the use of a simple balance

Procedure

Examine some coins. Discuss their differences.

Tell the class that a nickel weighs 5 grams. (Can be weighed if gram balance is available). Ask some person to measure several nickels across the middle.

Discuss the balance the class will use. Let them experiment with the balance and then assemble 5 gram sets.

Follow-up

(If gram balance is available). Have someone weigh a set of small objects weighing 5 g. Place the set in a plastic baggie and weigh again. Discuss the results.

Ask if any of the sets collected have five (or 10) members. If so, ask how much one (or 2) of those 5 members would weigh. Elicit the kinds of tiny objects that we can now weigh since we have a 1 g. object to use in the balance.

Letter some small objects A, B, C, D, etc. and have the children compute their weights using nickels and the set of objects having members that weigh 1 g. each.

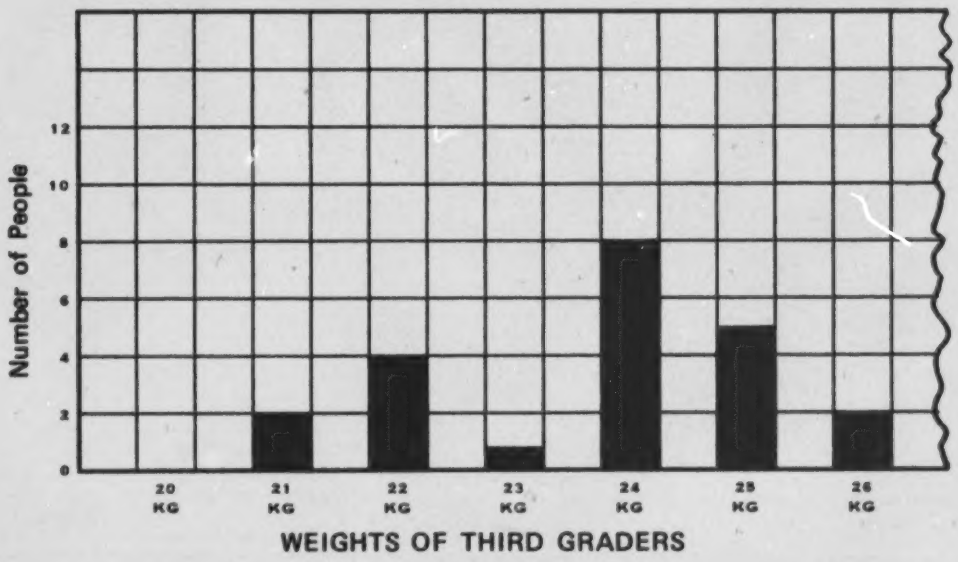
1 A 'tare' is the weight of the wrapping or the receptacle containing matter to be weighed.

Some Suggestions About Second Graders, Third Graders, and Bar Graphs

NEA and other educational authorities state that graph paper drawn in centimeter squares should be standard measuring equipment in our elementary schools. Using the cm often helps to imprint its size. Some second grade children, even if they can interpret a teacher-made bar graph made in cm squares, have real difficulty keeping their numerals small enough to fit into the square.

Some physically mature second and third graders can construct simple bar graphs using cm squares if the vertical data occupies the vertical space rather than straddle the line.

The horizontal data often represents fractional numbers and therefore has to be shown with the lines. Each horizontal axis may be used, but for clarity alternate vertical spaces should be used.



Even if a teacher prepares a graph of this sort for her class, it is a very effective way to present data to third grade children.

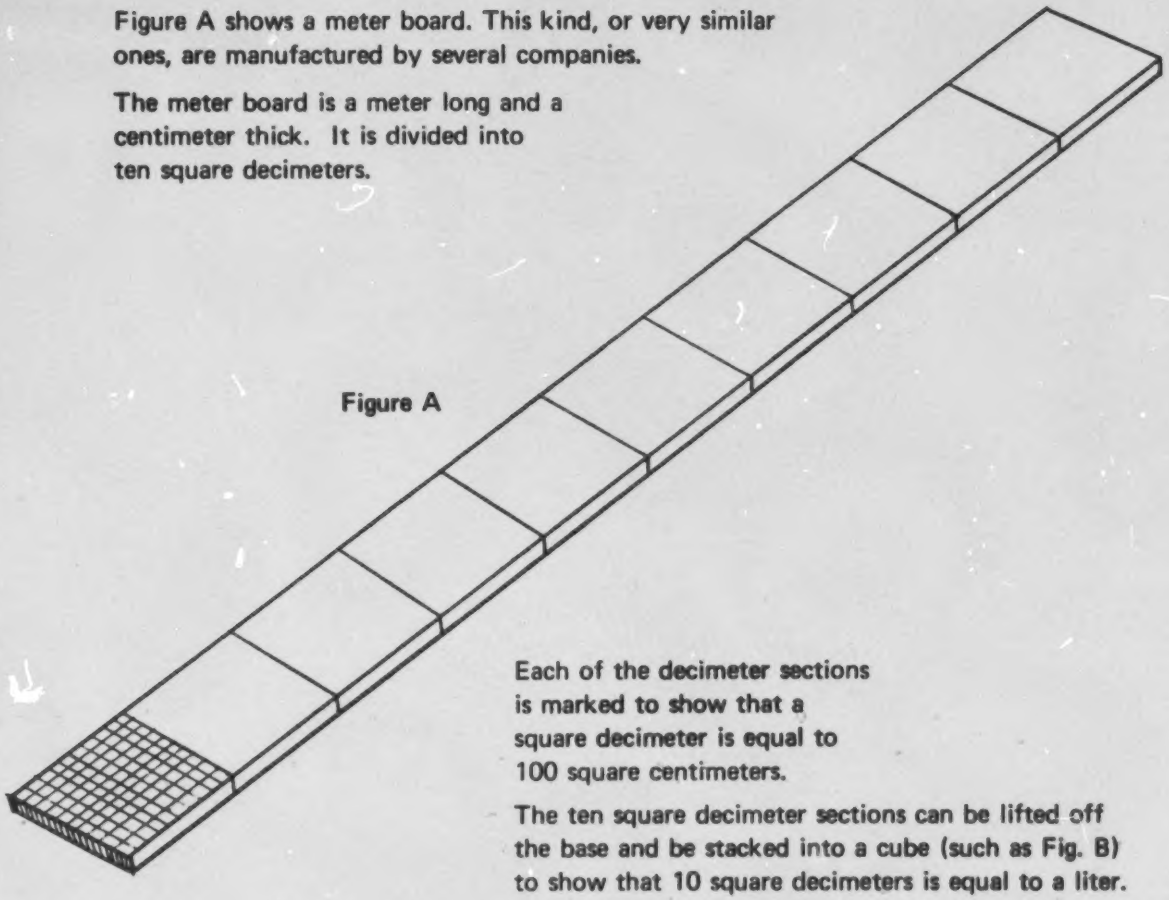
Vocabulary Third Grade Children Can Easily Use

legend	graph
horizontal axis	data
vertical axis	
origin	

Figure A shows a meter board. This kind, or very similar ones, are manufactured by several companies.

The meter board is a meter long and a centimeter thick. It is divided into ten square decimeters.

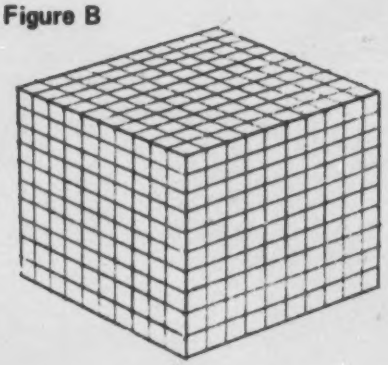
Figure A



Each of the decimeter sections is marked to show that a square decimeter is equal to 100 square centimeters.

The ten square decimeter sections can be lifted off the base and be stacked into a cube (such as Fig. B) to show that 10 square decimeters is equal to a liter.

Figure B

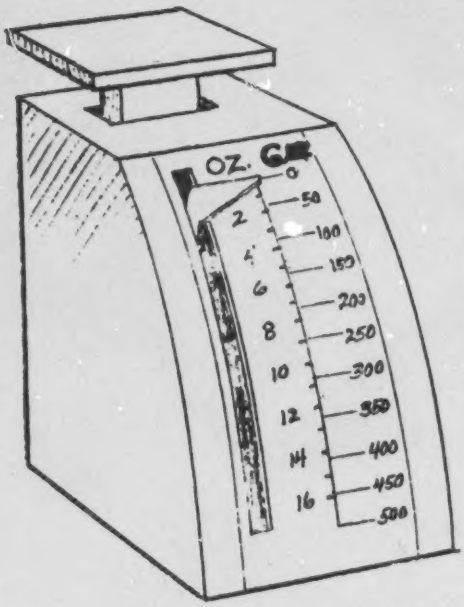


Several aids such as Figure B are available.

This stack of ten layers (each containing 100 sq. centimeters) comes in a lucite container (volume of 1 liter) to demonstrate the relationship of metric linear measurement to metric capacity measurement.

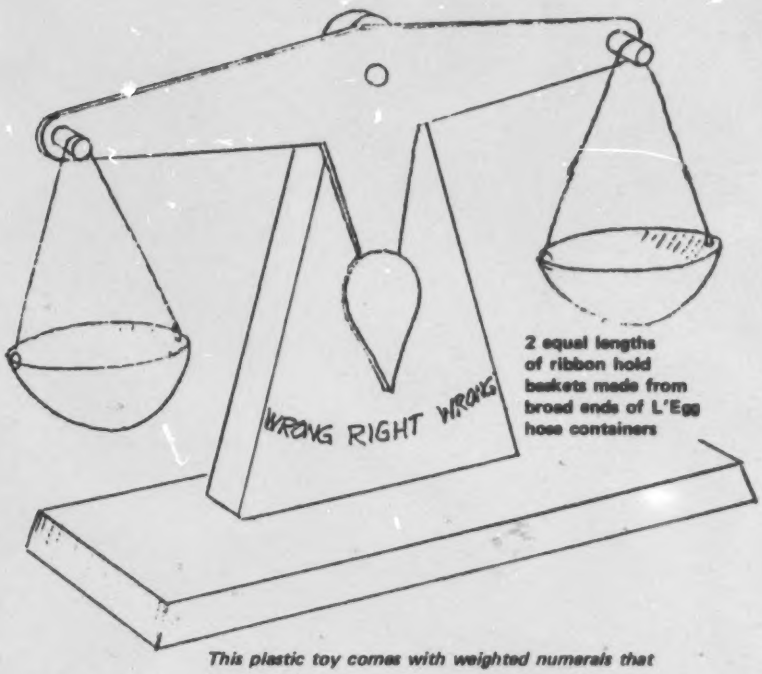
1 LITER = 1 cu. decimeter = 1000 cubic centimeters

Three Easy-to-get Scales



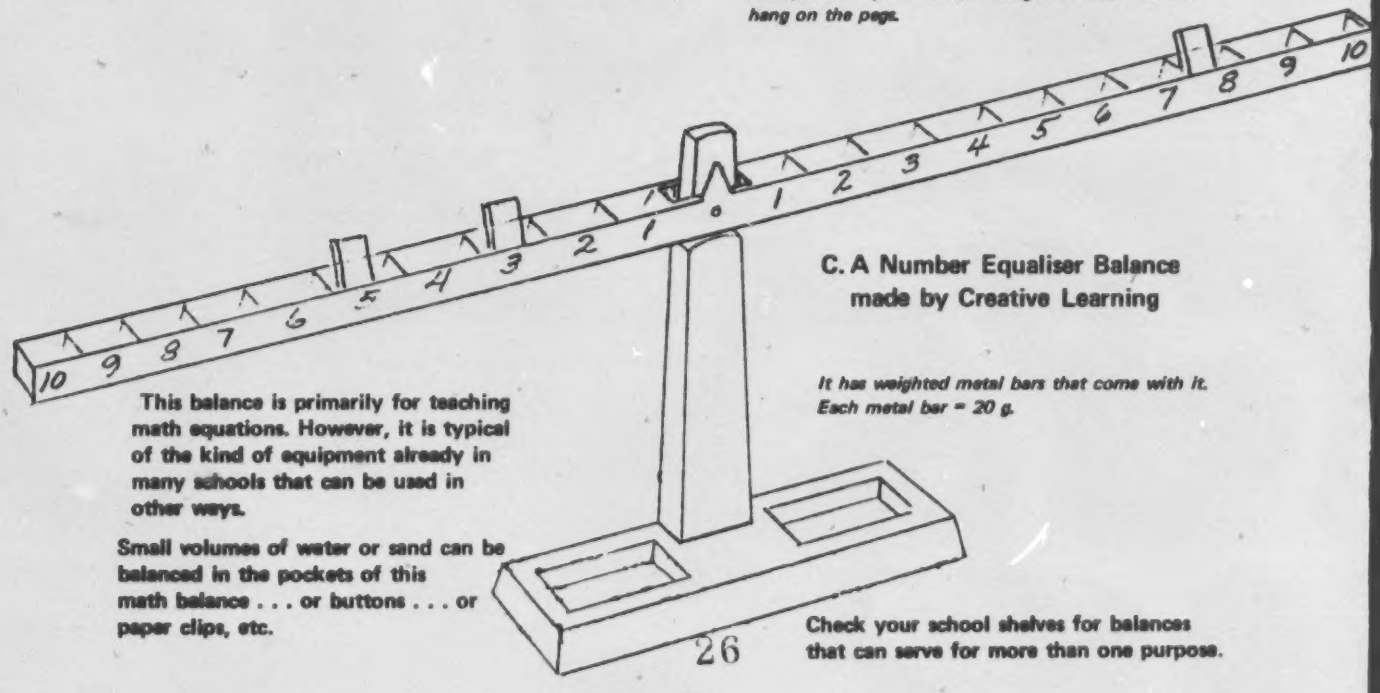
A. Inexpensive dieter's gram scale

B. Costs about $1.00.
A Child Guidance Toy (called ADD-A-Count)



2 equal lengths of ribbon hold baskets made from broad ends of L'Egg hose containers

This plastic toy comes with weighted numerals that hang on the pegs.



C. A Number Equaliser Balance made by Creative Learning

It has weighted metal bars that come with it. Each metal bar = 20 g.

This balance is primarily for teaching math equations. However, it is typical of the kind of equipment already in many schools that can be used in other ways.

Small volumes of water or sand can be balanced in the pockets of this math balance . . . or buttons . . . or paper clips, etc.

Check your school shelves for balances that can serve for more than one purpose.

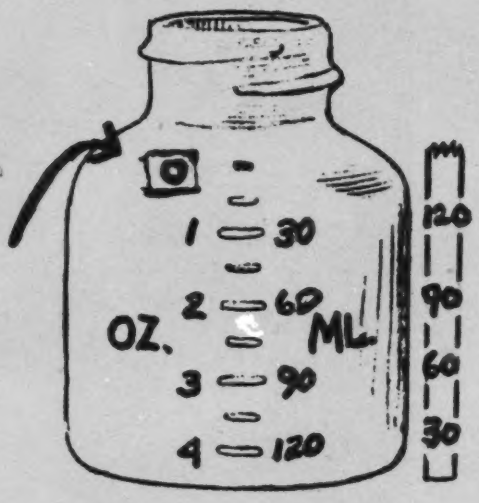
26

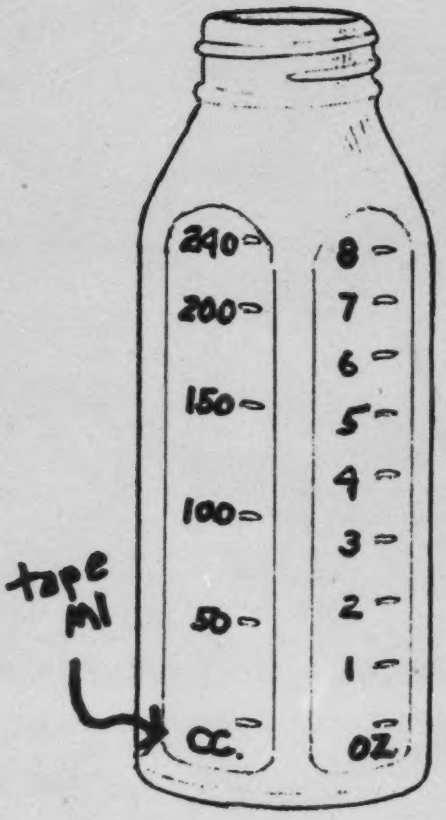
Several Activities Can Be Built Around A Baby Bottle

Older siblings are very willing to ask for the extra small-sized formula bottles. Many mothers have an excess now that prepared formula comes in them.

These advertising containers bear botn metric and English graduations. Some show the 120 ml at the bottom like the one on the right. Add a bit of tape at the top and mark the zero line.

It also helps to run a parallel tape and write the graduations with zero at the bottom.





The larger size bottle also comes with metric and English markings.

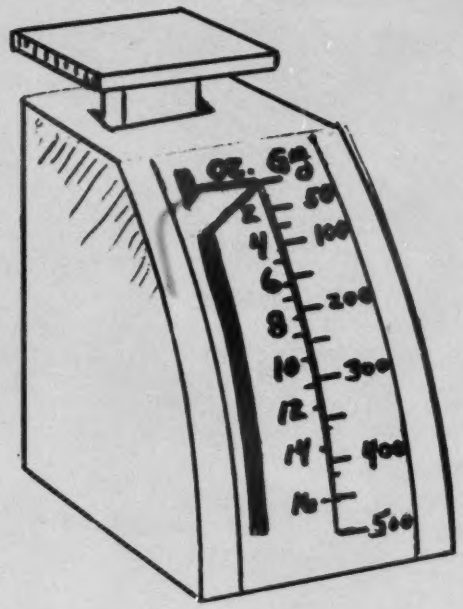
Some are labeled 'milliliters' while others say 'cubic centimeters'. If children ask about this they are satisfied to be told:

> "In the upper grades you will work with cubic centimeters. A cubic centimeter takes up the same space as a milliliter. For the time being we will just use the word milliliter when we talk about liquid in a bottle".

The capable and curious child may pour 50cc of water into a bottle with ml markings to prove to himself that the two terms are the same. In either case masking tape bearing the label you wish to use, can be added and will cause no confusion.

The larger size also is available in pretty colored non-breakable plastic!

A Suggested Activity
For Postal (or Diet) Gram Scale



Materials Needed

- The scale
- A simple display of different weights of paper
- A display of different weights and sizes of mailing envelopes
- A chart showing postal letter rates
- Some stuffed envelopes such as a family receives (these should be marked A, B, C, D, etc)
- A worksheet for each child to record his findings

Pupil Objectives

At the end of this activity the pupil will:

- be able to state that letters weighing up to 28g. need one stamp
- be able to explain why light weight paper is best for long letters

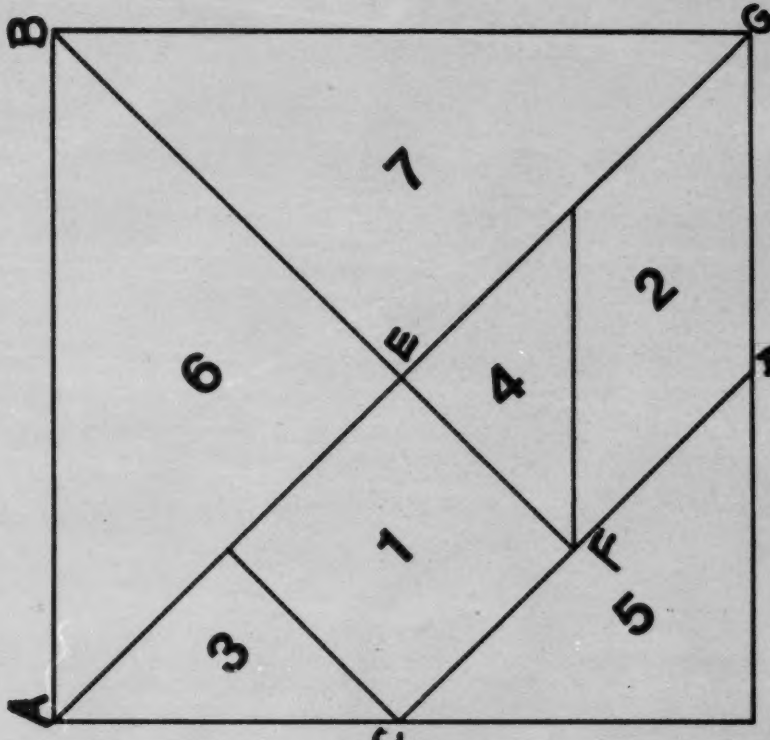
(These objectives can be extended for capable children)

Rationale

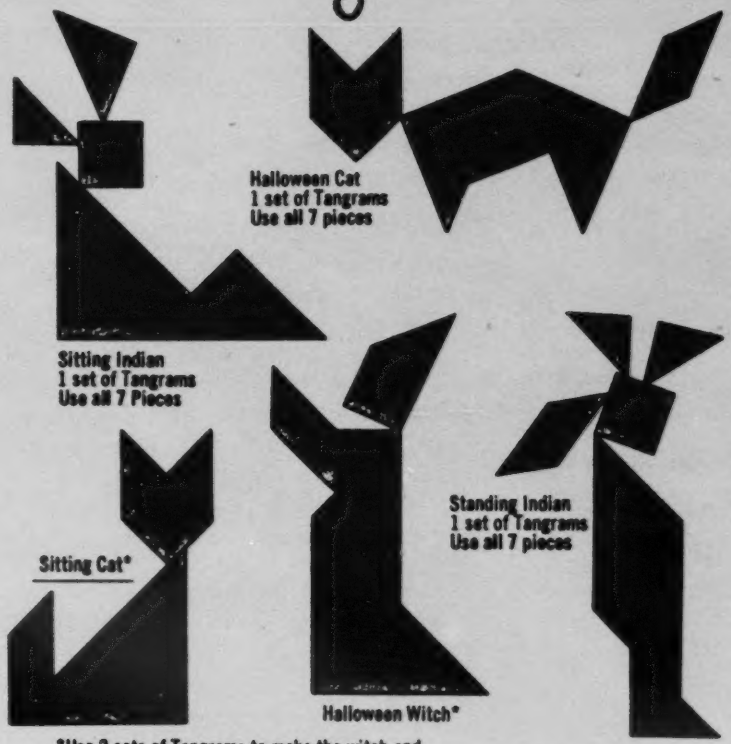
This kind of scale provides one more meaningful measuring experience to help children relate number values and concepts to everyday objects and everyday needs.

It can provide opportunities for simple multiplication problems for which children can see the application.

WORKSHEET FOR WEIGHING LETTERS		
	NUMBER OF 8 CENT STAMPS NEEDED	COST OF THE STAMPS
LETTER A		
LETTER B		
LETTER C		



"BEFORE CUTTING YOUR PUZZLE, MEASURE LINE AB IN CM'S. CHECK THE OTHER LINES. WAS A METRIC OR AN ENGLISH RULER USED?"



*Use 2 sets of Tangrams to make the witch and sitting cat.You must use all 14 pieces.

TANGRAMS AND PUZZLES – AND GEOMETRIC SHAPES TO BE MEASURED

Reproduce them in centimeters

– Use every opportunity to call attention to the size of the centimeter.

Grade Three Activity

Measuring Water Drop by Drop

Rationale

This activity introduces the child to the law of averages and provides him with meaningful activity – discovering how to get uniform sized drops from a medicine dropper. *

Activity

Ask: "How many drops of water are needed to fill a standard teaspoon to the point where the water is level at the top? Would all of us get the same count?"

Materials

Dropper for each participating child (or partners)
Standard teaspoon for each child
Small containers of water
Paper to record findings

Objectives

At the end of this activity the children will be able to:

- demonstrate how to get uniform drops of cold water from a dropper
- to explain why performing a task three times is desirable and more accurate
- to explain the term 'average'.

Procedure

Have three children demonstrate the use of the dropper. Ask those watching if all participants obtained the same results. If not, how did they differ?

Allow all children to practice first. Then ask each to fill his spoon to the level of its top counting the number of drops and recording them (three times).

Have them add the three totals and divide by 3.

On the chalkboard list the different averages and discuss them.

Follow-up

This task could be repeated using standard tablespoons.

The children could fill the droppers and find the average number of drops it holds.

* dropper should be held vertically. Child should squeeze very slowly and evenly.

PAGE 25 CONTAINING THE ARTICLE "WEIGHING SNOW"
FROM THE COPYRIGHTED MAGAZINE GRADE TEACHER WAS REMOVED
FROM THIS DOCUMENT PRIOR TO ITS BEING SUBMITTED TO THE
ERIC DOCUMENT REPRODUCTION SERVICE.

(Coloring sheets and activity sheets involving sports appeal to sports enthusiasts and promote the concept that metric terms are universally understood in the sports world.)

This young man is getting in shape for a hundred meter race. Can you draw some things around him so that the picture looks better?

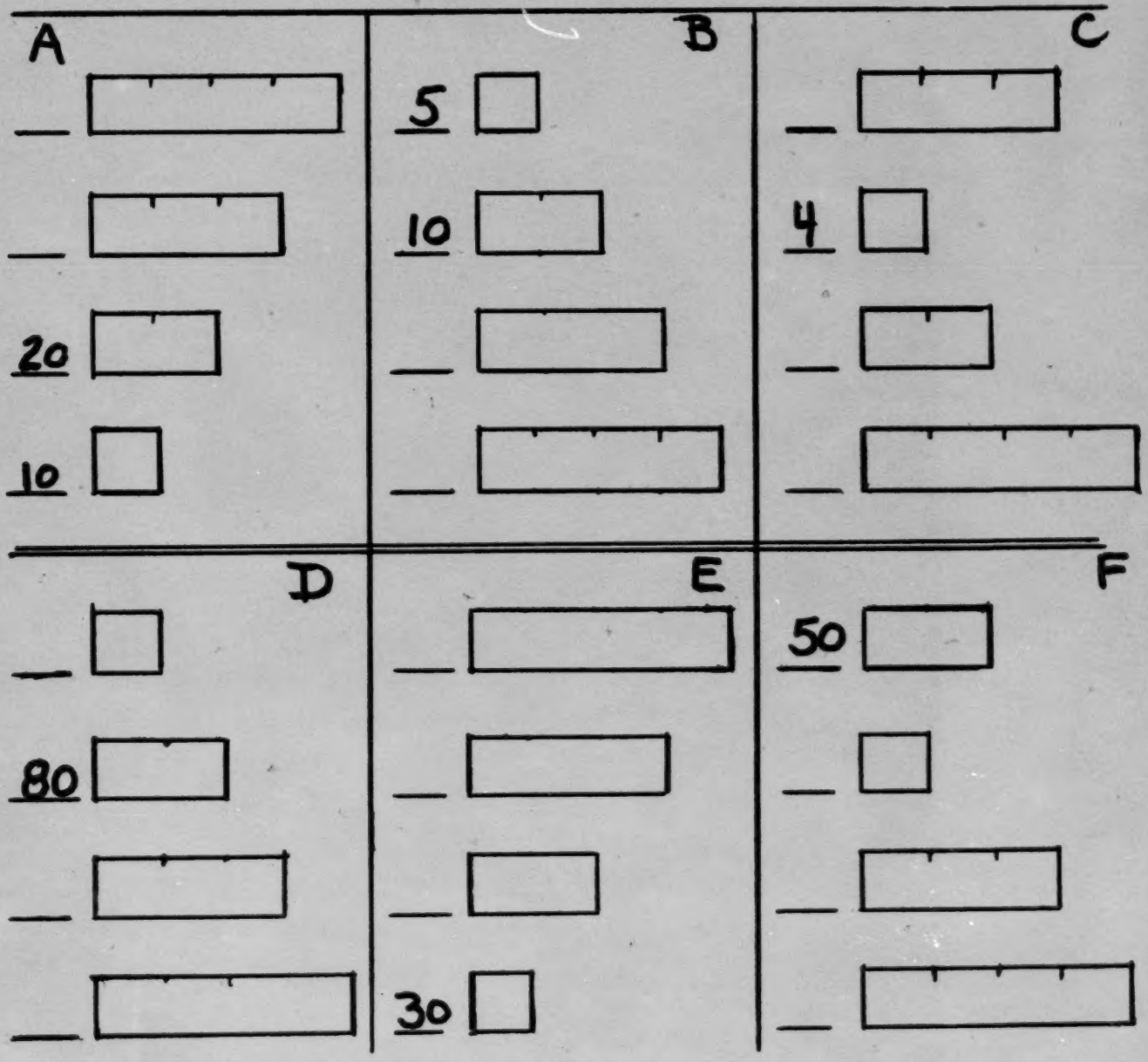
This page was xeroxed at The Center for Vocational Education, The Ohio State University because of copyrighted material on the reverse side.

Suggestion for a Math Ditto

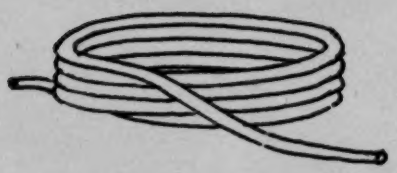
"In each of the sections below are 3 rectangles and 1 square. They are measured in centimeters. In Section A how many square centimeters could be placed in the first rectangle? In the second rectangle? In the last rectangle?

In section A let's say that the square centimeter represents a box that holds 10 kilograms of jelly beans. How many kilograms of jelly beans do the different rectangular boxes hold?

In each section you are to find the value of the centimeter square and then find the value of the larger figures. If it will help you may mark each rectangle into square centimeters."



A Suggested Use For A Coil of Plastic Clothes Line



It is a colorful teaching aid that is easy to obtain and with which children are familiar.

It is easy to store. It does not shrink or stretch like ordinary rope and it can be wiped clean.

It can be cut into lengths of one meter to provide a measuring unit for several children. Or masking tape can mark units on longer segments.

Activity

Measuring walls, floors, windows, big boxes and cylinders, etc.

Materials

a meter stick
some lengths of plastic line (1 meter long)
a length of line 10 meters (a dekameter)

Objectives

At the end of this activity the child will be able:

- to state that rope is a good measuring tool for measuring curved surfaces
- to state that a rope (several meters long) is helpful in measuring long rooms and halls, walks, railings along stairs, etc.
- to measure a room or hall with a rope

Procedures

Ask:

"Would one of these (meter ropes) short lengths of line be good to measure with? Why? Can anyone guess how long one of these is?" (Let a volunteer measure two or three of them)

"Would this line be as helpful as a meter stick? (Most children state that a meter stick is better because it has numerals and small lines, but often a child will contribute the fact that rope is good to measure curved things.)

Assign children to measure objects in classroom.

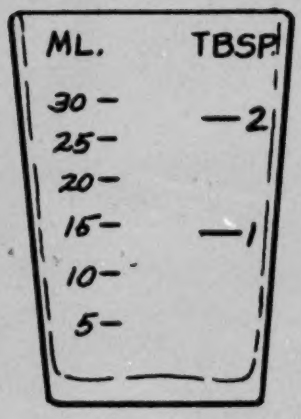
Follow-up

Ask:

"If a person had a job where he had to measure long rooms often, would one of our meter long lines be a tool he would use? (Answers vary but a child will suggest tying some of the meter ropes together. Another may suggest a longer rope)

Introduce the dekameter length (say it is 10 meters long rather than introduce 'deka prefix). Assign pairs of children to measure halls, room, etc.

Don't Overlook
The Tiny Garden Measure as a Teaching Aid



It appeals to children because of its size.

It's a device that the class can relate to everyday life.

Safety concepts can be built into a lesson when children can be shown how a tiny bit of concentrate can be added to a large amount of water and still result in a very dangerous mixture.

The garden measure manufactured by Science Products Co., of Chicago gives tablespoons, ounces and milliliters.

Objectives

At the end of this activity the child will be able:

- to show that using a concentrate is matching a small amount to a larger amount
- to state that concentrates save space
- to state that reading labels is important to safety

Materials

jar of colored water (jam jar size)
pail large enough to hold 5 liters
a garden measure
some label facsimiles
paper to record findings

BUG SPRAY CONCENTRATE

HARMFUL, KEEP OFF SKIN.
KEEP AWAY FROM CHILDREN.

ADD 10 ml. of CONCENTRATE
TO 1000 ml. WATER

Procedure

Discuss a label for bug spray and discuss its content. Discuss the garden measure. (Some child may say that it is like a small bar measure)

"How much of our make-believe bug spray would we need to use to make 1 liter for our sprayer? (10 ml)

How much of the bug spray would we need to use if we were to need 4 liters for spraying?"

Have some children actually measure the liquids while others draw sets to show matching.

Produce another fake label with different ratios.

Follow-up

Ask why a garden measure should only be kept for garden use.

Discuss other concentrates that have to be matched to large quantities before being used.

Produce a bottle of fruit punch and a kitchen measuring cup and match servings of punch to pupils.

Name _____ Date _____

In front of you is a box of sewing items to weigh. They each have a letter taped to them to help you identify them.

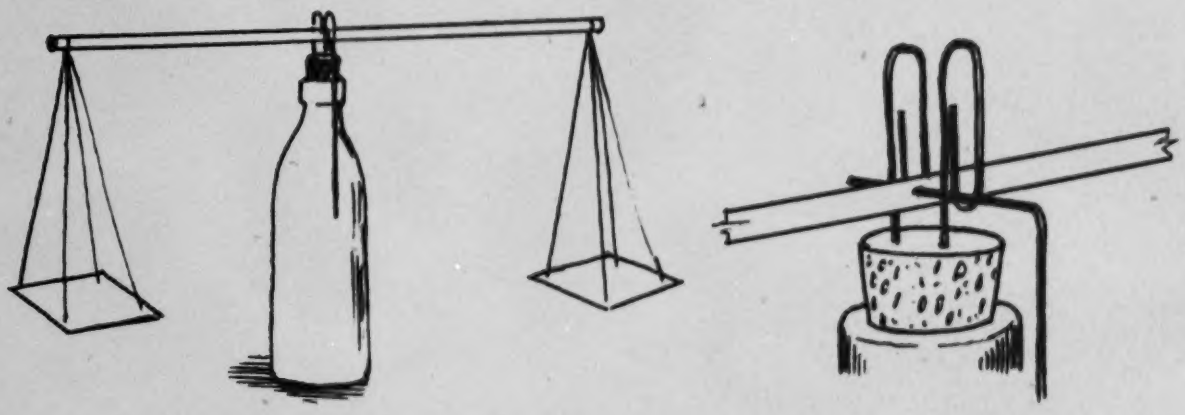
1. Weigh each item. Beside its letter record its weight and check the different gram balances you used.
2. When you have finished, you may check your answers. They are in the envelope on the back of this sheet. Please put them back in the envelope when you have checked your work.
3. Put your paper from this station into your file for the week.

ITEM	ITS WEIGHT	GRAM BALANCES YOU USED								
		1 g.	1 g.	2 g.	5 g.	5 g.	10 g.	10 g.	20 g.	50 g.
A. hard plastic spool, 5 cm.										
B. wooden spool 5 cm.										
C. small, empty wooden spool										
D. small, wooden spool with bit of green thread										
E. a measuring tape from a sewing kit										
F. a rectangular silver buckle										
G. two square silver buckles										
H. An octagonal plastic pin box (box is blue)										
I. three short metal zippers (a buncle)										
J. large white pearl button										
K. large brown button made of bone (or shell)										

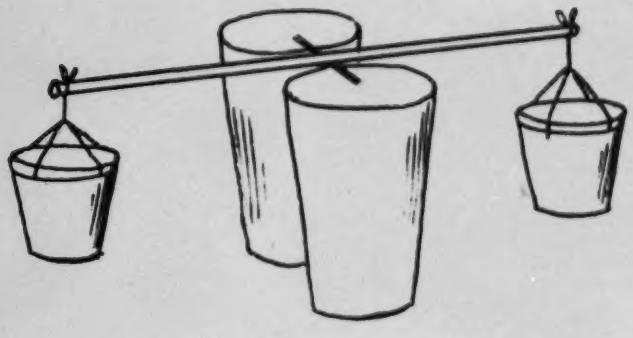
(Note to teacher: A follow-up of this activity is an assortment of hardware from a cellar workbench . . . lag bolts, bunch of washers, large cotter pin, etc)

Encourage the Building Of Improvised Balances!

Sketch No. 1 was taken from *Science and Children* (Jan/Feb 1971)



Sketch No. 2 from *Instructor* (April 1973)



Sketch No. 3 from *Instructor* (March 1973)

(Note: to increase the strength of a plastic straw, slit a second straw the vertical way with a scissor point, roll the second straw and slide it into the first one)

Measuring Class Heights and Weights

Below is a weight chart such as one might find in a third grade classroom. Present an exercise similar to the following fairly early in the school year, so that, upon completion of the school nurse's health inventory, a chart can be made with real weights and names.

Activity

Interpreting a simple weight chart

Rationale

It is expected that a third grade child has an approximate knowledge of his weight and that of his peers. A third grade child should have experiences in interpreting simple meaningful charts and graphs.

Material

A worksheet with a weight chart and some pertinent questions and problems. Or a chart can be made on the chalkboard and the questions given as part of a group discussion.

Objectives

At the end of this exercise the pupil will be able:

- to state his approximate weight
- to state the approximate weight of most third grade pupils
- to interpret data from a simple weight chart

WEIGHT CHART		lb.
HENRY	30 kg.	(65)
BETTY	26 kg.	(58)
DICK	25 kg.	(55)
SALLY	21 kg.	(47)
ANN	24 kg.	(52)
BOB	22 kg.	(49)
MARK	25 kg.	(56)
MARY	23 kg.	(51)
BILL	29 kg.	(63)
SUSAN	22 kg.	(49)
PAUL	30 kg.	(65)

Procedure: Ask:

How many children weigh less than 25 kilograms?
How many children weigh more than 25 kilograms?
Which person is the lightest? etc.
How much would Dick and Henry weigh together?
If Sally and Paul were each on one end of a seesaw, who would be higher?
etc. etc.

Follow-up

Make a class weight chart.
Make a simple bar graph of the class weights.
Make a class heights chart . . and bar graph.

Weights and Measures

From *Grade Teacher* (Feb. 1971)

Prof. Herman C. Kranzer (Univ. of West Florida) gives the following as ideas for a file card in your "Math Problem Box"

Question:

How thick is a piece of paper?

Hint:

You can't measure one single piece, so start with a number of them the same size. Now proceed.

Write your answer here

Question:

What is the weight of one paper clip?

Hint:

Since it would be difficult to get the exact weight of one paper clip, start with a number of them.

Now find the weight of one.

Question:

Do you weigh more in or out of the bath?

Hint:

Wait! Don't jump into the tub yet. Place a string around a stone several times to form a net. Weigh the rock on a spring scale. With the stone still attached to the scale, drop it in a jar of water. Does it weigh more or less? Has the weight of the stone changed?

Write your answer here.

Question:

Your body is 98.6° fahrenheit. What is it on the centigrade scale?

Hint:

To convert to centigrade, the formula is C= (F - 32) X 51 ⁝ 9

Write your answer here. _____

Now convert other temperatures such as the freezing and boiling points of water.

Write your answer here. _____

Now convert these temperatures back from centigrade to fahrenheit. This formula is

F = (9C ⁝ 5) + 32

THE CELSIUS THERMOMETER
(centigrade thermometer)

One can teach elementary grade children about the thermometer using a few worksheets and a cardboard/ribbon aid! However, it is fun when the temperature readings are from real thermometers and the children are pondering over open-ended activities. One dozen classroom centigrade thermometers cost around $4.00 and permit active learning such as:

- Discovering if temperatures within the classroom vary.
- Discovering if temperature varies within a refrigerator.
- Discovering ways to raise and lower the temperature reading on a thermometer (without breaking it).
- Discovering what temperature changes will occur as snow, or ice cubes melt in a cup.
- Discovering what materials make good insulation (Wrap various materials around a bottle of hot - or ice water - to prevent heat from passing out of or into the water).
- Discovering if the temperatures of animals vary? Or if our own temperatures vary at times during the day.
- Discovering if the snow on the playground varies? Is it the same on the ground, under the snow, in the snow at top? Does snow act as an insulator?
- Discovering how the addition of salt affects ice and snow temperatures. Would other substances such as sugar or baking soda create any temperature changes?
- Discovering if temperature makes any difference in the way a ball bounces. How do golf balls, tennis balls, ping-pong balls bounce in winter cold?
- Discovering about temperatures around the school yard in the green season. Compare the temperature on the black top and on white cement . . . . .on green grass and a green car . . . . .on a light colored car and a dark car . . .on sand and on black soil . . .on clothing of different colors.
- Discovering how to classify such terms as hot, warm, and cold water/ Is cool the same as cold?

The above suggestions for open-ended activities are given in the March *Instructor* (1973). The writer, Professor Richardson suggests giving children experiences such as these (alone or in pairs) to learn about 'hotter' and 'colder'.

MEASURING WHEELS ARE FUN!

Commercially made wheels are available, but often the budget doesn't have funds available for all the interesting teaching gimmicks. Below is a plan for constructing one. Naturally wood is more durable, but heavy cardboard will stand up under careful classroom usage.

Measuring wheels can be made to cover a meter or two meters . . . or any arbitrary unit you may choose.

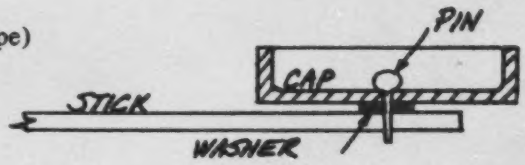
Once your measuring wheel has been constructed have one child measure a long distance with it, while another child checks the distance with a rope or a meter stick.

LET INTERMEDIATE GRADERS MAKE SOME SMALL MEASURING WHEELS AND EXPERIMENT WITH THEM.

This activity will help to reinforce the concept of the approximate 3 to 1 ratio of the diameter and circumference.

Provide a collection of: (and encourage class to add to it)

small bottle caps (preferably plastic)
popsickle sticks
rubber gaskets (plumbing repair type)
pins with large heads
- corsage pins
- bulletin board push pins



With a compass point gently make a pin hole through a bottle cap and the end of a popsickle stick. Insert the large-headed pin through the plastic cap and then through the stick. With wire clippers snip off most of the protruding pin. Or try inserting a bulletin board push-pin through a lid followed by a solid-type faucet washer and ending with the popsickle stick.

OR . . . . you can create cardboard circles having circumferences of such that when the class records the radius of each disk, then the diameter and the circumference, he will see the pattern.

And . . . . bottle caps with 2 or 3 cm diameters will give intermediate graders practice in working with millimeter and centimeter circumferences.

Estimating Lengths and Heights Of Large Objects Using Scale Drawings

Children like to discuss prehistoric monsters and which of them could fit into the classroom or the school gym. Below is a list of some large creatures and large objects that might be useful in creating some scale drawings such as those that appear on the following page.

Prehistoric animals	feet (length)	meters
brontosaurus	70 feet	21m
stegosaurus	18	5.5m
diplodocus	90	27.5m
protoceratops	6	1.8m
triceratops	30	9.2m
allosaurus	30	9.2m
tyrannosaurus	40	12.2m
Railroad cars		
coach	69	21m
sleeping car	72	22m
dining car	85	26m
Animals		
horse	7½ high	
elephant	8 ft. high, 8½ long	
mouse	2½ in.	5cm
large dog	36 in.	1m

Not all authorities agree on the exact measurements of dinosaurs, so teachers can easily round off metric measurements to omit fractional numbers . . . . or teachers can stretch them to make them even meters.

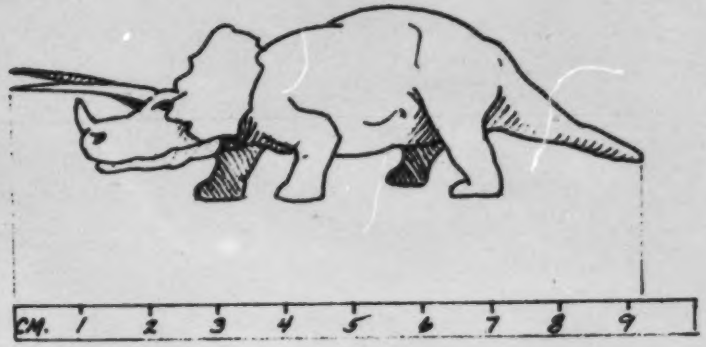
Third grade children would have no problem in interpreting the scale drawing of the triceratops which appears on the following page . . . . or the wren. However, the last dimension (1/100) should be omitted for primary grades.

For third and fourth grade children the stegosaurus could be described as 6 meters (which would make it larger than the above list) and shown as 20 cm. Say: "In this drawing each centimeter represents a set of 30 centimeters. 20 cm x 30 cm =?"

Primary children – and many intermediate – need to measure off 6 meters – or 20 meters – before they can discuss places where large objects can fit. A bulletin board of dinosaurs and other animals is helpful when they are asked if they can name something that is the same length, or height, as these subjects are being discussed.

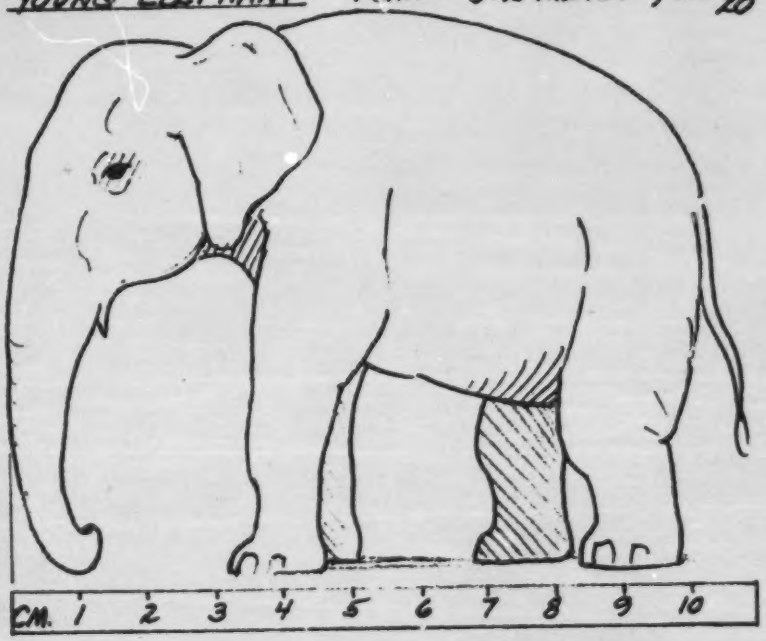
TRICERATOPS

1 CM. = 1 METER, OR $\frac{1}{100}$



37

YOUNG ELEPHANT 1 CM. = 0.2 METER, OR $\frac{1}{20}$

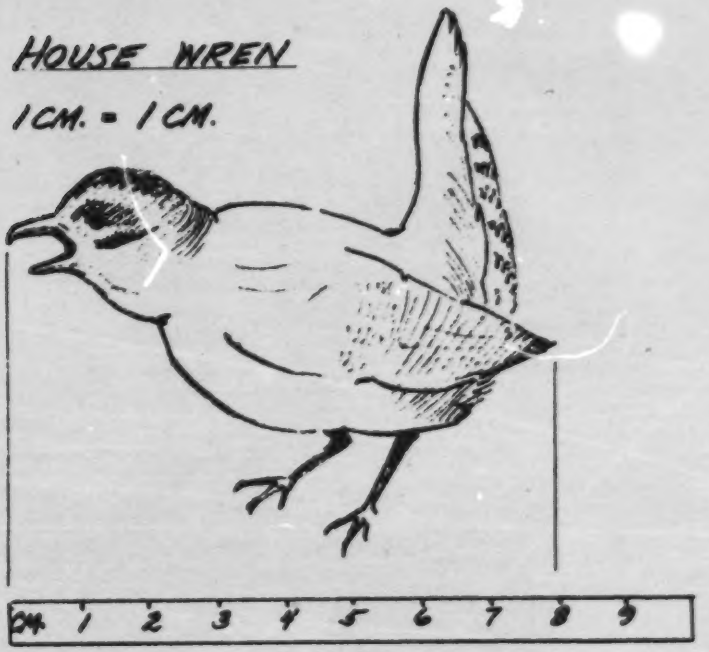


PROTOCERATOPS

1 CM. = 0.2 METER, OR $\frac{1}{20}$

HOUSE WREN

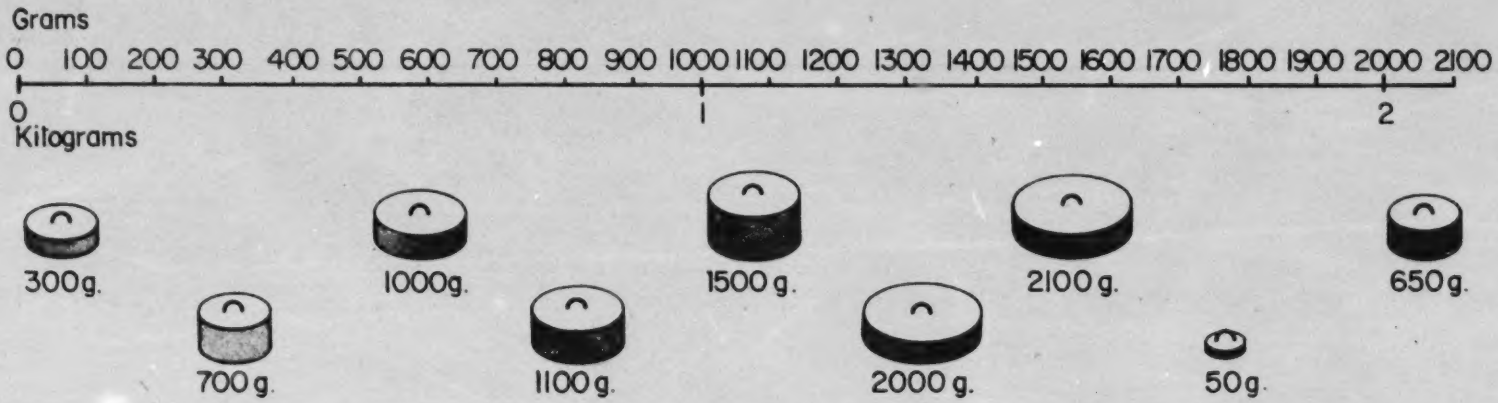
1 CM. = 1 CM.



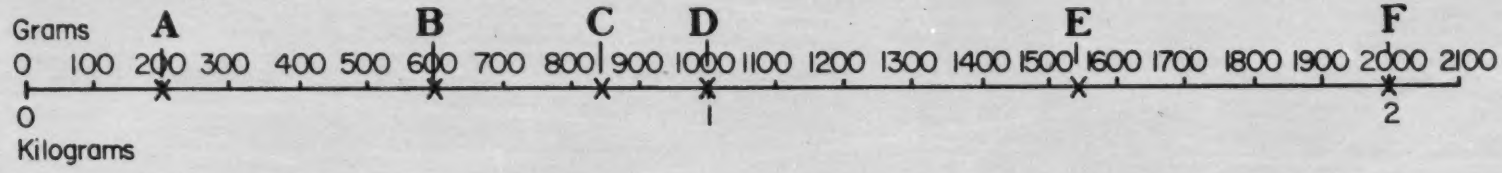
IDEAS

Name _____

Put an X on the line for each metric weight.



Name each of these points.

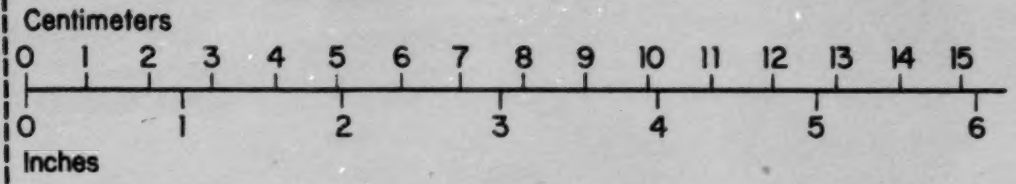


A _____ grams **B** _____ grams **C** _____ grams **D** _____ kilograms **E** _____ grams

F _____ grams **D** _____ grams **F** _____ kilograms

IDEAS

Name: _____



Put an X on the line for each measure.

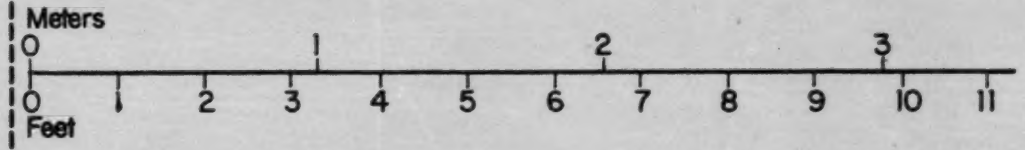
2 inches $3\frac{1}{2}$ inches 5 inches

10 centimeters 5 centimeters 1 centimeter

Use the number line to approximate the metric measure for each English measure.

2 inches, ____ centimeters 4 inches, ____ centimeters

$5\frac{1}{2}$ inches, ____ centimeters



Put an X on the line for each measure. (Remember: 100 cm. = 1meter)

3 feet 2 meters $6\frac{1}{2}$ feet

150 centimeters 9 feet 10 inches $2\frac{1}{2}$ meters

Use the number line to approximate the metric measure for each English measure.

$3\frac{1}{4}$ feet, _____ meters 8 feet, _____ meters

5 feet, _____ meters

For Teachers

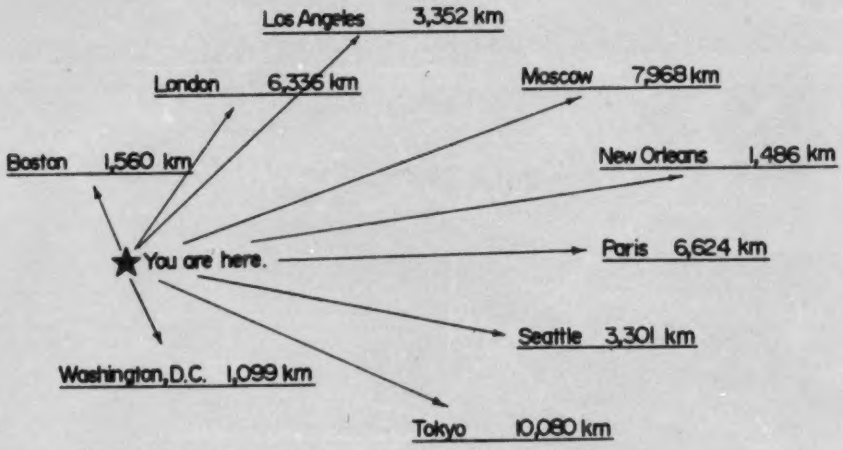
Objectives: Experience in relating basic metric units of weight using a number line model

Levels: 2 or 3

Directions for teachers:

1. Remove the activity sheet and reproduce a copy for each student.
2. Hold up some familiar objects such as a chalkboard eraser labeled 52 grams and a book labeled 525 grams. Have each student use his pencil to show each weight on his metric number line.
3. Have students do the first set of exercises on the activity sheet. Note that the abbreviation for grams is used on the drawings.
4. Ask if any of the weights shown could have other names (1000 grams = 1 kilogram and 2000 grams = 2 kilograms).
5. Have students do the remaining exercises. The second set of exercises helps to focus on the two names for special points on the metric line.

Comments: These activities are not meant to replace experiences that build the student's basic referent for units of metric weight. Prior to using this activity sheet, the student should have personal experience in weighing familiar objects using metric scales.



Where are you?

The Arithmetic Teacher

Curriculum Content
For Grade Levels Four, Five, and Six

Kinds of measure to be taught:

1.	**Length** (linear)	Basic unit is the meter.
2.	**Mass** (weight)	Basic unit is the gram.
3.	**Temperature**	Basic unit is the Celsius degree.
4.	**Time**	Basic unit is the second.
5.	**Area** (surface measure)	Refer to reference chart for teacher.
6.	**Volume** (capacity)	
7.	**Money** (no change in content Money is already taught with decimal and is metrically measured)	

VOCABULARY FOR GRADE LEVELS FOUR, FIVE, AND SIX

The following words are different combinations of terms and prefixes which have, for the most part, already been introduced. Refer to the vocabulary page for grade levels one, two, and three.

Grade Four

decimeter
centimeter
millimeter
dekameter
hectometer
kilometer (now introduced as a unit of measure)

deciliter
milliliter
dekaliter

centigram
milligram
decigram

Grade Five

hectogram
dekagram

square centimeter
square decimeter
square meter

Grade Six

Cubic meter
cubic decimeter
cubic centimeter

GRADE FOUR OBJECTIVES

At the end of this grade level the pupil will be able:

- to define the standard prefixes (milli, centi, deci, deka, hecto, kilo)

Linear

- to maintain and extend earlier skills using the meter, and its related units
- to state the number of meters in a dekameter, a hectometer, a kilometer
- to estimate length and width of items in room in meters

Mass (weight)

- to identify the gram, centigram, milligram, decigram, kilogram
- to weigh matter using a gram scale
- to list some familiar kinds of matter weighed in grams and kilograms
- to state the approximate average weight of a fourth grade person in kilograms

Temperature

- to maintain and extend earlier ideas about the Celsius thermometer
- to state the freezing point of water ($0^{o}C$)
  boiling point of water ($100^{o}C$)
  body temperature ($37^{o}C$)
  room temperature ($21^{o}C$)
- to explain why the Celsius thermometer is often called the centigrade thermometer

Money

(These objectives coincide with Fourth Grade Math objectives)

Capacity

- be able to measure liquids to the nearest milliliter
- to name some common items that would be measured in liters and milliliters

FIFTH GRADE OBJECTIVES

Linear

- to extend earlier skills and apply them to Fifth Grade math problems

Mass (weight)

- to extend earlier skills and apply them to Fifth Grade math problems
- define a dekagram and a hectogram

Temperature

- to maintain and extend earlier skills and concepts
- to compare Celsius readings with Fahrenheit (no conversion)

Area (length and width)

- to describe a square meter, a square decimeter, and a square centimeter
- to draw a square meter and a square decimeter
- to demonstrate how area increases by factors of 100
  (Eg. 1 sq. meter = 100 sq. decimeters)
  (1 sq. decimeter = 100 sq. centimeters)

Capacity

- to maintain and extend all earlier ideas and skills and relate them to Fifth Grade math problems

SIXTH GRADE OBJECTIVES

At the end of this grade level the pupil will be able:

Linear

- to maintain and extend earlier skills and concepts
- to identify the prefixes, mega and micro, as 10^{0} (or 1,000,000) and $1/10^{6}$ (or 1/1,000,000)
- to demonstrate the use of metric measurement in measuring and figuring circumference

Mass (weight)

- to maintain and extend earlier skills and concepts
- to state that a metric ton = 1000 kilograms
- to read and manipulate the metric-customary converter, a supplied item, as a supplement (avoid conversions)

Temperature

- to maintain and extend earlier skills and concepts

Area (length and width)

- to maintain and extend earlier skills and concepts
- define the are (1 are - 100 sq. meters)
- define the hectare (1 hectare = 100 ares)

Volume (capacity or length times width times depth)

- to figure or calculate simple volumes when given specific data
- to state that 1 cubic decimeter = 1 liter = 1000 cubic centimeters
- to state that cubic measure increases by factors of 1000
  (Eg. 1 cubic meter = 1000 cubic decimeters
  1 cubic decimeter = 1000 cubic centimeters)

Some Activities to Develop Concepts About Area Levels Four, Five, and Six

1. Finding the area of desks, books, floor tiles, table tops, room, school yard using cm^2, dm^2, and m^2
2. Marking out specified areas in chalk.
3. Finding combinations. Eg. $48m^2$ = 6m X 8m, 4m X 12m = ?.
4. Making oak tag cutouts to show cm^2 and dm^2
5. Making oaktag cutouts of odd varied sizes
6. Measuring area of box surfaces
7. Having children make up area problems for their peers
8. Exercises to make them familiar with fact that a square = X^2
9. Exercises to help children develop skill in understanding that area progresses by factors of 100 ($625\ cm^2 = 6.25\ dm^2$)
10. Exercises in land measurement using the are and hectare as terms
11. Making graph paper designating cm^2 and dm^2

Some Aids and Hints To Help Develop Concept of Volume

1. Have children measure classroom objects using the three dimensional measurements. Use three dimentional objects such as cuisenaire rods, books, desks, etc.
2. Use metric rulers to compute the volume of math books in cubic centimeters . . . . compute a desk eraser in cubic millimeters . . . . compute the volume of the classroom in cubic meters.
3. Provide exercises requiring conversion to the next smallest unit to show that this requires moving the decimal point three places to the right.

   Eg. 20.658 cubic meters = 20658. cubic decimeters . . . . and moving the decimal point three places to the left is converting to the next largest multiple

   Eg. 3658 cubic centimeters = 3.685 cubic decimeters

   In other words, develop concept that **volume** increases by factors of 1000

   Eg. 1 cubic meter = 1000 Cubic decimeters = 1,000,000 cubic centimeters

   or

   $1\ m^3 = 1000\ dm^3 = 1{,}000{,}000\ cm^3$

(Continued on Page 45)

SOME AIDS AND HINTS TO HELP DEVELOP CONCEPT OF VOLUME (cont)

4. Use cuisenaire rods to construct volumes of various sizes in cubic centimeters.

   Problem: Construct a volume of 32 cm^3
   a. Factor into three factors (2 X 4 X 4)
   b. Build a figure 2 cm X 4 cm X 4 cm)

   Problem: Construct a volume of 30 cm^3
   a. Factor into three factors (2 X 3 X 5)
   b. Build a figure in cm rods

   Note: When using cuisenaire rods make sure to choose a volume that is factorable to three **whole** numbers. Prime numbers (29, 101, 31, 19, etc) will not work; although such volumes will exist having one or more **decimal** dimensions.

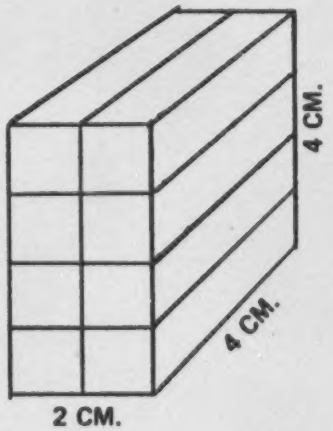
5. Use centimeter-sized centicubes as in No. 4 activity

6. Provide activities to show the relationship of the liter to volume.
   - 1 cu. decimeter = 1 liter - 1000 cu. centimeters = .001 cu. meter
   - 10 liters = 10 cu. decimeters = 10,000 cu. centimeters = 01 cu. meter
   - 1000 liters = 1000 cu. decimeters = 1,000,000 cu. centimeters = 1 cu. meter

7. Demonstrate how volume and capacity (the liter) are derived from length.

8. Demonstrate how weight (mass) is also derived from length.
   Eg. 1 gram is defined in terms of 1 cubic centimeter of water at 4°C at sea level.

   Note: The meter is therefore the 'grandaddy' of most all units of metric measure.



Note: Cuisenaire rods can be borrowed from a primary classroom.

Have Pupils Form Associations Between Familiar Objects and the Metric Units of Measure

The hand span measurement was suggested as an activity to help primary graders think about centimeter measurement. Also in previous pages it was suggested that third graders study a weight chart showing weights in kilograms.

Upper elementary children need to think about their body measurements in metric. Scouts are often asked to learn their approximate body measurements as a basis for judging outdoor distances and sizes of objects. Their notebook might have a page similar to this:

- My height . . . . . meters . . . . . centimeters
- From ground to tip of upstretched fingers . . . . meters . . . . . centimeters
- My reach from one outstretched hand to the other . . . . . meters . . . . . centimeters
- Hand span . . . . . centimeters
- Length of foot . . . . . centimeters
- Length of step . . . . . centimeters

Have class make a chart showing the above information and then ask them to list some part of their hand that would be very close to one centimeter in length; then a part of their hand that is quite close to a decimeter in length. Using the ever-ready body measurements have the class make a list of nearby familiar objects to associate with the various metric units. Lists will vary according to the recent class interests and involvements. Consider a list similar to this class effort:

Centimeter
kindergarten pencil
little finger (thick)
width of popsickle stick
head of spike nail

Decimeter
thumb-tip to wrist
width of folded road-map
width of a 2-qt. milk carton

Meter
a door
a hedge bush
hood of a car
door-knob from floor
2 newspages

Gram (weight)
weight of a nickel
8 paper clips 2.5 cm long
plastic pen cap
8 small nails

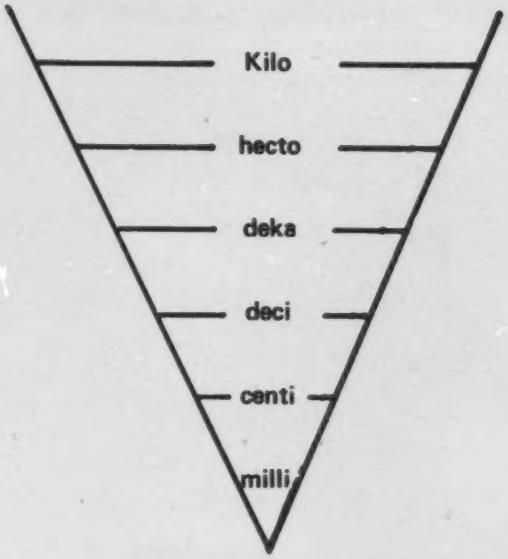
Kilometer
10 football fields
battleship
Empire State Building

Kilogram
9 bars oleo
a shoe
a dictionary

Liter
contents of 4 baby bottles
what your stomach holds

As it was stated above, lists vary. The main objectives is to help children begin to associate measurement with everyday experiences and familiar objects.

THE LADDER of PREFIXES



The above pictures are quite helpful as the class members begin to solve problems involving all the common prefixes.

Word games can be assigned such as:

How many words can you find that include "cent"?
(cent, century, centigrade, centipede, centennial . . .)

How many words include the word-part 'meter'?
(speedometer, odometer, thermometer, etc)

Or have the class think of simple fingles that define, or give clues, about the metric units.

The metric prefix ladder am I.
I get fatter as you climb toward the sky.
On the way down I get much thinner-
Know my rungs and you'll be a winner.

The decimeter you shouldn't dread.
It's only the width of a slice of bread.
Ten slices of bread placed side by side
Is an open-faced sandwich a meter wide,
A very long sandwich a centimeter thick!
To eat it all would be quite a trick!

10 meters *a deckameter is larger than a mouse*
It's about the length of a little house!

100 meters *a hectometer would be hard to steal!*
It's a bit longer than a football field.

1000 meters *A kilometer is a long way to go.*
It's about half a mile. Or did you know?

A Project to Measure Area And Construct a Quadrate

If a class is lucky enough to have an open-field area near their school, this project provides a good excuse to go outdoors. This project involves math, measuring, prediction, observation, and recording data.

Activity

Class members assume roles of ecologists and scan an open-field area and classify the five most prevalent kinds of plant and animal life. Class also constructs a classifying area according to the accompanying sketch.

Materials

- Plastic clothesline 12 meters long and marked off in 5 meter intervals (use felt-tip pen with permanent ink)
- wooden right angle (60cm x 80 cm x 100 cm)
- 5 wooden stakes
- length of *sturdy* string (at least 60 meters)
- mallet to drive stakes, a meter stick
- insect sweeper, jars to collect insects

Objectives

At the end of this activity the class will be able to:

- construct a rope enclosure 10 meters square
- be able to explain how ecologists predict plant growth in a given community
- classify prevalent plants in a community
- estimate animal life in a community area

Procedure

Choose an open-field area (low grasses and weeds) large enough to construct an enclosure 10 meters square. Before the class begins work, ask:

"If we were ecologists who wish to predict how this open-field area will look in ten years, providing no digging is done here, how might we study this area and draw some conclusions?"

(Look at kinds of plants on land nearby and look for evidence of other living things that can change land)

"Why couldn't we count every kind of plant here?"

"Why couldn't we possibly count every animal?"

"Suppose we were to rope off a small part of this open-field area to study the most abundant plants, how can we decide which part to enclose?"

(Throw a stick in the air and the spot where it falls will be the center of the enclosure)

Assign people to construct the quadrate (or quadrates if there is room for more than one)

Assign a team to observe the most abundant plants in the square meter quadrate and to order them and assign symbols to them. Record the five plants.

Have class compare the square meter area plants with the rest of the roped-off plant community. Compare the roped-off area with the surrounding area. Ask:

"What observations can we make within our $10m^2$ – and without it – that will help us predict this land's future plant growth?"

(Continued on Page 49)

(construction of a quadrate 10 m^2 continued)

Ask:

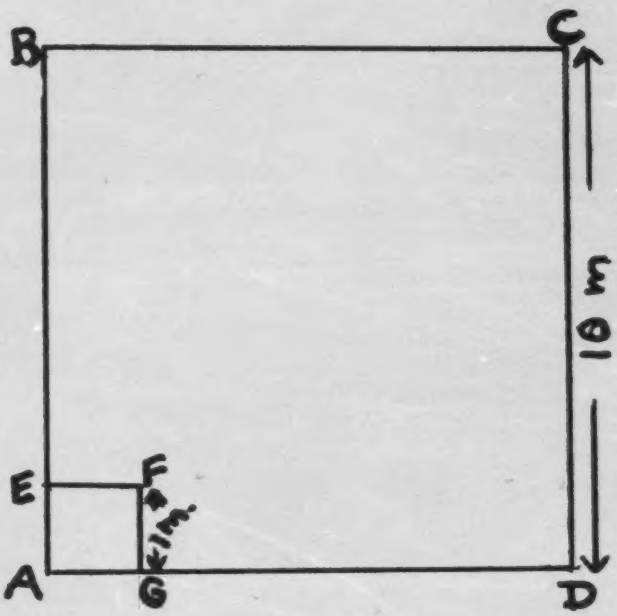
"How might we get a sampling of animal and insect life within our quadrate?"

(Use insect sweeper)

"Provided the land is not dug up, and plants are allowed to grow, will the animal life within our quadrate change? . . . . will the animal life around our quadrate change?"

Assign someone to sweep the **square meter** and classify, order, and record the results.

Quadrates may be 5m X 5m. Or teams of two can be set up each having a square meter area to observe and report about. On low grasses, a stiff wire of 354 cm bent into a circle will cover an area equal to a square meter.



To construct the quadrate:

Begin at A and extend rope 10M.
Drive stake B. At stake A use wooden right angle to extend line AD. Drive stake D.
At D use right angle to get direction for line DC.
Drive stake C.
Using right angle and meter stick, find Points E, F, G.
Drive stake at F.

(teacher note: An are is a metric term for an area of 100 sq. meters)

A simple insect sweeper can be made from a pillow slip stapled around a coat hanger loop.

Blue Whale

The elephant may be used
to compare sizes of the whales.

Pilot Whale

Pygmy Whale

KINDS OF WHALES

Sperm Whale

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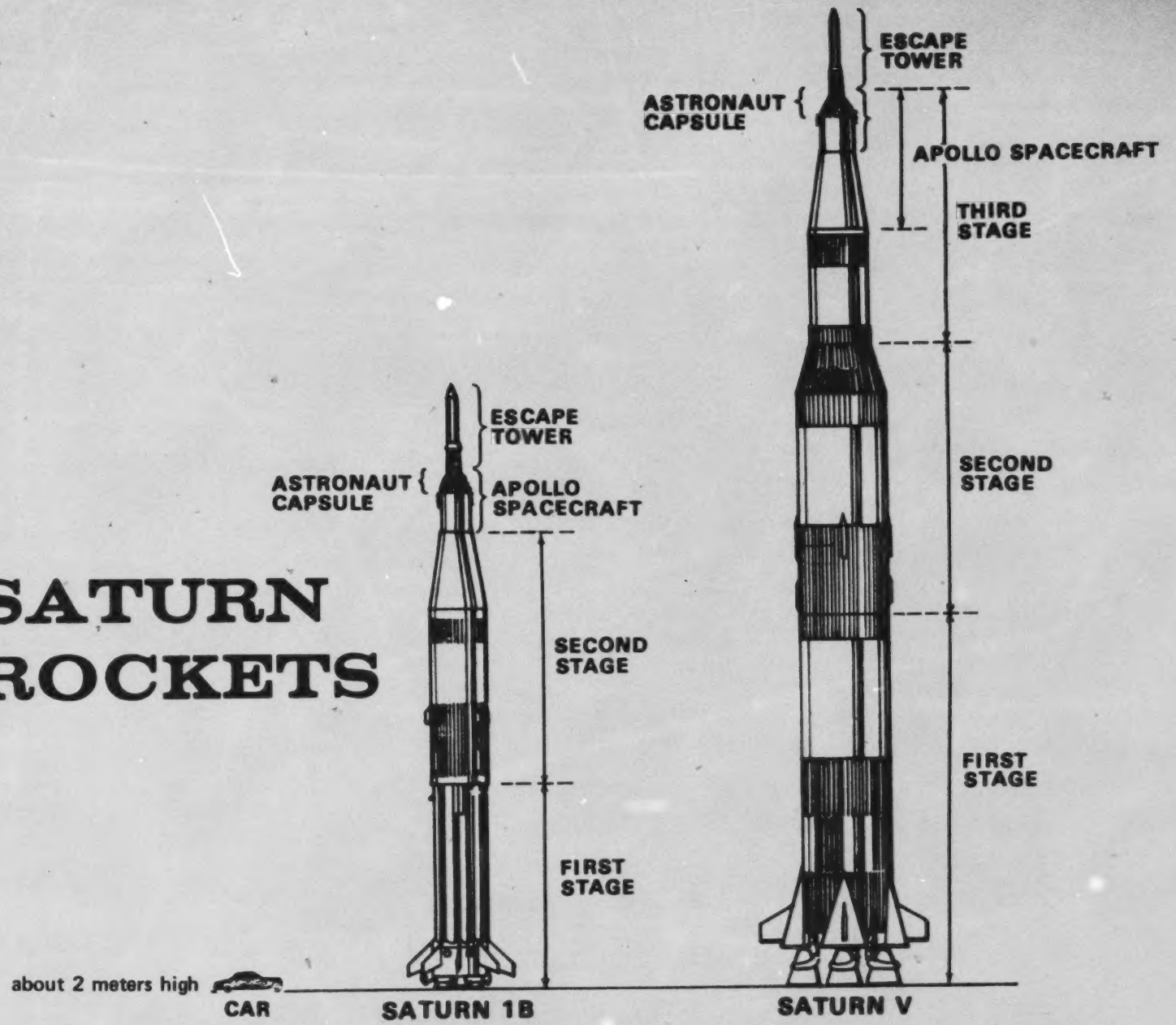
SATURN ROCKETS

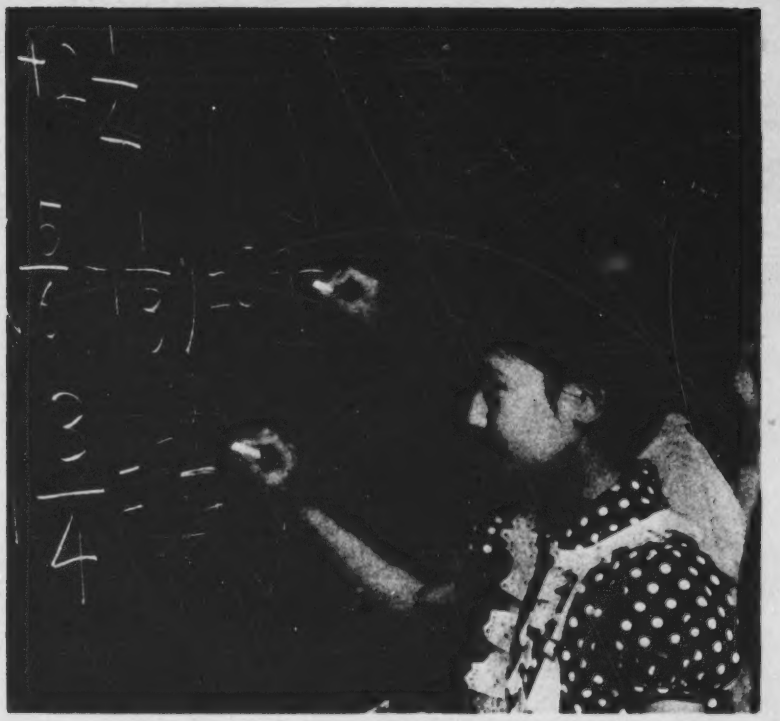


The yard, measured in days of old
Was from nose out to where you could hold.
So when George checked on Martha
Their yardage was farther
Apart than they would have dared told!

62

The contest has been quite a thriller
"Miss Metric" is how we will bill her.
Her form's a sensation
But her specification
Seems better to suit a gorilla!

63



"The National Education Association has urged that . . . all children be taught metric as the primary language of measurement."

Scene:	An elementary classroom – fifth grade – in 1993

Mr. Jones: Ms. Smith! Why are you teaching your class such fractions? When could they possibly use them?

Ms. Smith: I don't teach the whole class such fractions! Just the ones who need enrichment . . . and challenge.

Mr. Jones: It would be a challenge for me to refresh myself well enough in the old-time, infrequently used fraction combinations so that I could teach them!

British teachers estimate that they used to spend 15 to 25 percent of their math time driving home the details of adding, subtracting, multiplying, and dividing in fractions. (fact taken from *A Metric America*)

Possibilities for Research Projects for Upper Grades

- What reasons might be given for Jefferson's plan not being adequately studied or promoted?
- What activities would Benjamin Franklin have been pursuing that would have exposed him to metric thinking? Do you think he would have favored the French system? Why?
- Explain the Dewey library system. What experience would have led Melvin Dewey toward such a system?
- Can you explain why radioactivity is measured in curries?
- Interview a druggist. Find out what tools he has for measuring liquid and solid volumes?
- Interview a jeweler. Why would jewelers have been early in the general use of metric measurement?
- Interview a member of the Model Railroad Association or a Circus Model Builder. Or go to a hobby store and investigate the scale of measurement most commonly used in model kits.
- Make a list of the different current sports events and tell which ones would be most difficult to describe in terms of metric measurement.
- Investigate metric time. Make a list of problems that would be involved with a conversion to a ten-hour clock.
- Investigate current coins from other countries that are metric. Eg. A U.S. nickle weighs 5 grams and measures 2 cm in diameter. All our coins are carefully weighed.

Junior and Senior High Section

It is the opinion of the Metric Committee that the three basic units to be mastered in the elementary grades are the meter, the gram, and the liter. Elementary grade teachers are encouraged to read this last section to help them understand how elementary measuring skills will be maintained and extended.

Junior and senior high teachers are encouraged to study the course contents and objectives outlined in the preceeding pages for the elementary grades. Some of the information in these pages may be of value even in the upper grades.

SCIENCE (Junior High – Senior High)

The junior high and senior high science department curriculums are already totally metric and it is in this area of higher education that *all of the six basic metric units* will be taught. The curriculum contents are contained within the pages of their respective textbooks. Some examples would be these national curriculums:

IPS, IPS2, IMB, IME, ITTS LIFE SCIENCE, and ESCP

The science department (both junior and senior high) should attempt to teach the metric system by itself so that pupils and teachers learn to think in this language of measure. They should not attempt to teach the metric system through conversion problems and conversion factors, but should teach the metric system by itself.

Behavior objectives are to be established by a special committee which will meet during the 1973 summer school session. When the results of this committee are available they will be incorporated into the science department's curriculum, and, hopefully, into this report.

MATHEMATICS (Junior High – Senior High)

The junior high and senior high mathematics departments should teach the metric material as it appears in their respective textbooks and should supplement it with other available metric information.

(Junior - Senior High – *Continued on next page*)

COOKING

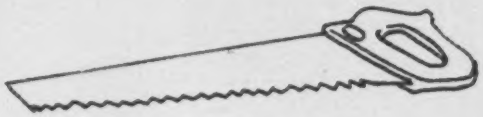
Objectives:

- to measure weight in grams (kilograms, hectograms, dekagrams, decigrams, centigrams, and milligrams)
- to measure liquids in liters (deciliters, centiliters, and milliliters)
- to read metric recipes
- to mix ingredients in the proper proportions
- to bake, broil, boil, and fry food at metric temperatures

CLOTHING

Objectives:

- to measure material by the meter, decimeter, centimeter (length)
- to measure material using square centimeters and square decimeters (area)
- to construct clothing using a metric pattern



WOODWORKING

Objectives:

Seventh and Eighth Grades

- to measure to the nearest centimeter

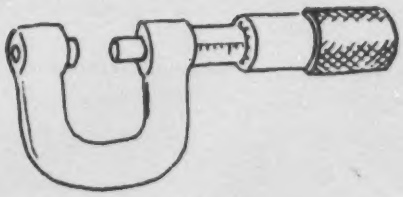
Ninth Grade

- to calculate board footage in metric measurement

Senior High

- to make any measurement to the nearest centimeter
- to demonstrate the use of all metric tools used in the woodworking trade

(Junior - Senior High – *Continued on next page*)



METAL WORKING

Objectives:

Seventh Grade

– to measure to the nearest centimeter

Eighth Grade

– to measure in dekameters, hectometers, and kilometers

Ninth Grade

– to measure to the nearest millimeter
– to demonstrate the use of a micrometer and a vernier

Senior High

– to maintain and extend earlier measuring skills
– to read a metric working drawing
– to explain a chart giving metric thread standards
– to use metric fasteners
– to use all the precision tools of the trade
– to use a conversion chart

MECHANICAL DRAWING

Objectives:

Seventh Grade

– to dimension drawings to the nearest millimeter

Eighth Grade

– to construct drawings giving dual dimensions

Ninth Grade

– to maintain and extend earlier skills
– to define specific metric nomenclature such as: surface finish symbols, metric thread nomenclature, and center-line indication

POWER MECHANICS

Objectives:

Senior High

- to perform all measurement and precision measurement in the metric system
- to use and read capacity measures (liter)
- to demonstrate the use of specialized metric tools used in the repair and maintainance of automobiles
- to determine the capacity (liters) of radiators, crankcases, and gas tanks
- to interpret metric thread terminology
- to select the proper metric fasteners

ELECTRICITY/ELECTRONICS

In this area the metric system is the sole system for measurement and computation. As new discoveries are made, or new tools or formulas are introduced, objectives will be updated, and students will be taught the needed skills.

HOME MECHANICS

Objectives:

Seventh Grade

- to measure wood to the nearest centimeter (length, width, volume)
- to to define amperes, volts, watts, and ohms

Eighth and Ninth Grades

- to maintain and extend earlier skills
- to explain and check amperage, voltage, and wattage
- to explain and measure resistance in ohms

THINK

The following pages are intended to be background and reference material for the Teacher in the intermediate grades.

Do not try to digest it in one gulp unless you are a metric whiz.

Do not use it as a teaching guide or manual.

Refer to it often, however, to build on your own knowledge in order that you may come to thinking metric.

METRIC

BASE TEN & THE METRIC SYSTEM

The metric system was divised to simplify the mathematics of measurement and to eliminate all forms of measurement which do not conform to powers of 10.

The word power is used to denote that a number has been multiplied by itself a number of times.

The table below shows how we use exponents (powers) to simplify the writing of expressions with several factors.

FOR THIS PRODUCT	WE THINK	WE WRITE	WE SAY
10x10	10 used as a factor 2 times	10^2	10 to the 2nd power, or 10 squared
10x10x10	10 used as a factor 3 times	10^3	10 to the 3rd power, or 10 cubed
10x10x10x10x10	10 used as a factor 4 times	10^4	10 to the 4th power
10x10x10x10x10	10 used as a factor 5 times	10^5	10 to the 5th power
10x10x10x10x10x10	10 used as a factor 6 times	10^6	10 to the 6th power

The numbers 10^2, 10^3, 10^4, and so on are called powers of ten. Ten is called the base. The numbers written in the upper right are called exponents. The powers are 100, 1,000 and 10,000 respectively.

METRIC PREFIXES

Metric prefixes are used with all units of measure. They are based on ten, and simply name multiples of the basic units.

PREFIX	ABBREVIATION	NUMERICAL VALUE	LENGTH LINEAR	WEIGHT MASS
Mega	M *capital letter*	1,000,000	1,000,000 meters or 1 megameter	1,000,000 grams or 1 megagram
Kilo	k	1000	1000 meters or 1 megameter	1000 grams or 1 kilogram
Hecto	h	100	100 meters or 1 hectometer	100 grams or 1 hectogram
Deka	da	10	10 meters or 1 dekameter	10 grams or 1 dekagram
gram	g	1	Basic unit of measure	
			X Prefixes are used with these X	
meter	m	1	Basic unit of measure	
Deci	d	.1 or 1/10	.1 meter or 1 decimeter	.1 gram or 1 decigram
Centi	c	.01 or 1/100	.01 meter or 1 centimeter	.01 gram or 1 centigram
Milli	m	.001 or 1/1000	.001 meter or 1 millimeter	.001 gram or 1 milligram
Micro		.000001 or $\frac{1}{1,000,000}$	.000001 meter or 1 micrometer	.000001 gram or 1 microgram

METRIC MEASURES
Prefixes For The Metric System

micro – means one millionth
milli – means one thousandth
centi – means one hundredth
deci – means one tenth

(From Latin)

deca – means ten
hecto – means one hundred
kilo – means one thousand
Mega – means one million

(From Greek)

Linear – LENGTH – Basic Unit – METER

10 millimeters (mm) = 1 centimeter (cm)
10 centimeters = 1 decimeter (dm)
10 decimeters = 1 meter (m)
10 meters = 1 dekameter (dam)
10 dam = 1 hectometer (hm)
10 hm = 1 kilometer (km)

UNIT	DECIMAL DESIGNATION	FRACTIONAL DESIGNATION	EXPONENTIAL DESIGNATION
kilometer	1000	1000	$10^{\frac{3}{3}}$
hectometer	100	100	10^2
dekameter	10	10	10^1
meter	1	1	10^0
decimeter	.1	1/10	$1/10^1$ or 10^{-1}
centimeter	.01	1/100	$1/10^2$ or 10^{-2}
millimeter	.001	1/1000	$1/10^3$ or 10^{-3}
micrometer	.000001	1/1000000	$1/10^6$ or 10^{-6}

WEIGHT – MASS – BASIC UNIT – gram		
10 milligrams (mg)	=	1 centigram (cg)
10 cg	=	1 decigram (dg)
10 dg	=	1 gram (g)
10 g	=	1 dekagram (dag)
10 dag	=	1 hectogram (hg)
10 hg	=	1 kilogram (kg)
1000 g	=	1 kg
1000 kg	=	1 metric ton

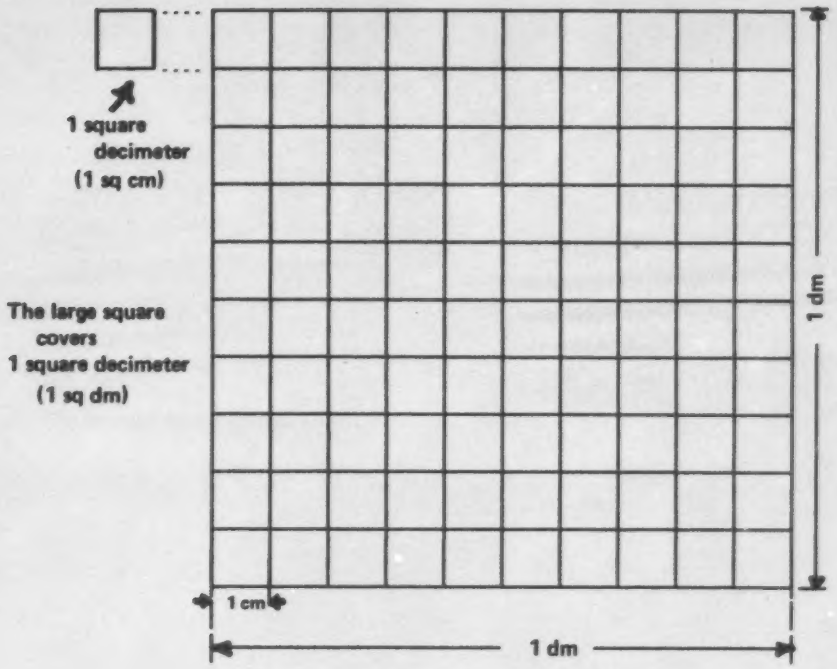
CAPACITY – BASIC UNIT – liter		
10 milliliters (ml)	=	1 centiliter (cl)
10 cl	=	1 deciliter (dl)
10 dl	=	1 liter
10 liters	=	1 dekaliter (dal)
10 dal	=	1 hectoliter (hl)
10 hl	=	1 kiloliter (kl)

meter = 1,650,763.73 wave lengths in a vacuum of the orange-red radiation of Krypton 86

gram = weight of 1 cubic centimeter or a milliliter of water

liter = one cubic decimeter

METRIC UNITS of AREA



UNITS	SYMBOL	RELATIONSHIP OF UNITS
square centimeter	cm^2	$1\ cm^2 = 100\ mm^2$
square decimeter	dm^2	$1\ dm^2 = 100\ cm^2$
square meter	m^2	$1\ m^2 = 100\ dm^2$
are	a	$1\ a = 100\ m^2$
hectare	ha	$1\ ha = 100\ a$
square kilometer	km^2	$1\ km^2 = 100\ ha$

AREA = increases by factor of 100 length x length

75

METRIC UNITS of VOLUME

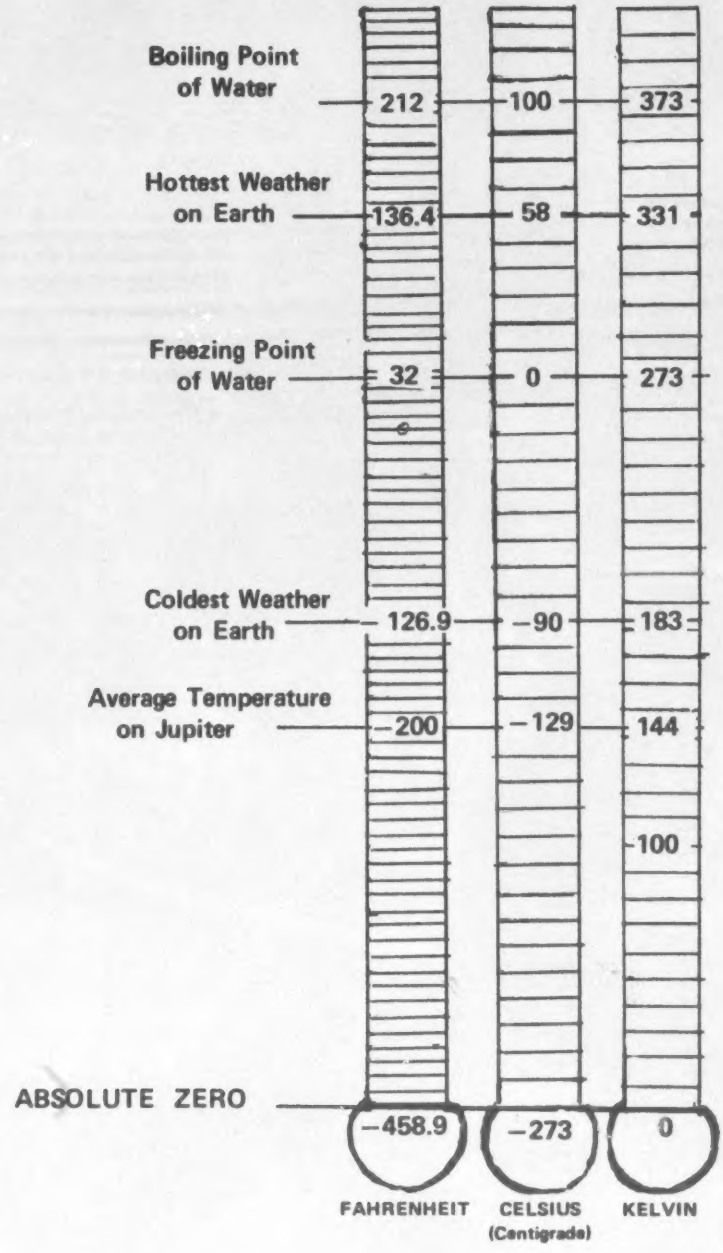
THE VOLUME OF A FIGURE IS THE NUMBER OF CUBIC UNITS IT WILL HOLD

1 cubic centimeter
(1 cc)

UNITS	CUBIC SYMBOL	RELATIONSHIP OF UNITS	LITERS
cubic centimeter or milliliter	cm^3	$1cm^3$ = .001 liter = 1 ml	ml
cubic decimeter 1 liter	dm^3	1 dm^3 = 1000 ml = 1 l	l
cubic meter	m^3	1 m^3 = 1000 l = 1000 dm^3	1000 l

Volume = increases by factors of 1000 **length x length x length**

TEMPERATURE



100° = boiling point of water 0° = freezing point of water

CELSIUS → FAHRENHEIT $(C° \times \frac{9}{5}) + 32 = F°$

FAHRENHEIT → CELSIUS $(F° - 32) \times \frac{5}{9} = C°$

METRIC/CONVENTIONAL TIME Conversion

CONVENTIONAL	METRIC
1:00 a.m.	0.4170
2:00 a.m.	0.8340
2:24 a.m.	1.0000
3:00 a.m.	1.2510
4:00 a.m.	1.6680
4:48 a.m.	2.0000
5:00 a.m.	2.0850
6:00 a.m.	2.5020
7:00 a.m.	2.9190
7:12 a.m.	3.0000
8:00 a.m.	3.3360
9:00 a.m.	3.7530
9:36 a.m.	4.0000
10:00 a.m.	4.1700
11:00 a.m.	4.5870
12:00 noon	5.0000
1:00 p.m.	5.4170
2:00 p.m.	5.8340
2:24 p.m.	6.0000
3:00 p.m.	6.2510
4:00 p.m.	6.6680
4:48 p.m.	7.0000
5:00 p.m.	7.0850
6:00 p.m.	7.5020
7:00 p.m.	7.9190
7:12 p.m.	8.0000
8:00 p.m.	8.3360
9:00 p.m.	8.7530
10:00 p.m.	9.1700
11:00 p.m.	9.5870
12:00 midnight	10.0000

BASES

24 - hr/60 min./60 sec. day

10-hr/100 min./10^{o}sec. day

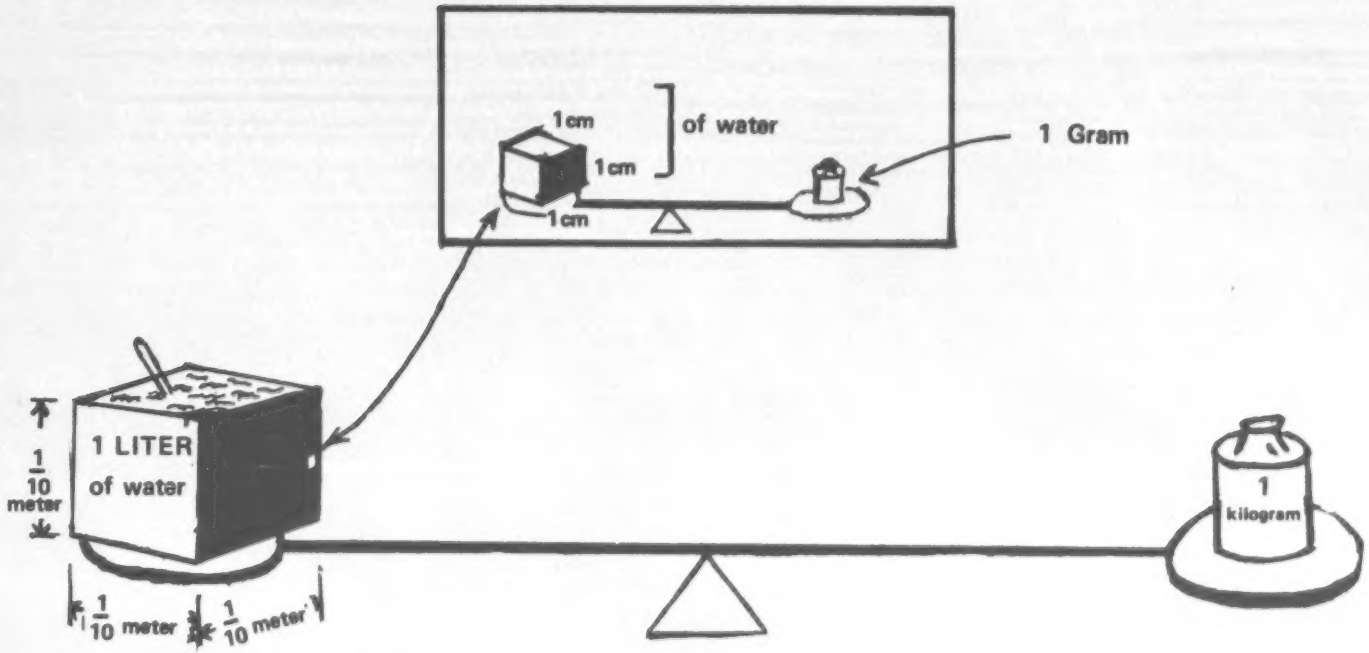
A Metric Day would consist of 10 hrs.

100 minutes – 1 hour

100 seconds – 1 minute

1 metric hour – 2 2/5 conventional hours

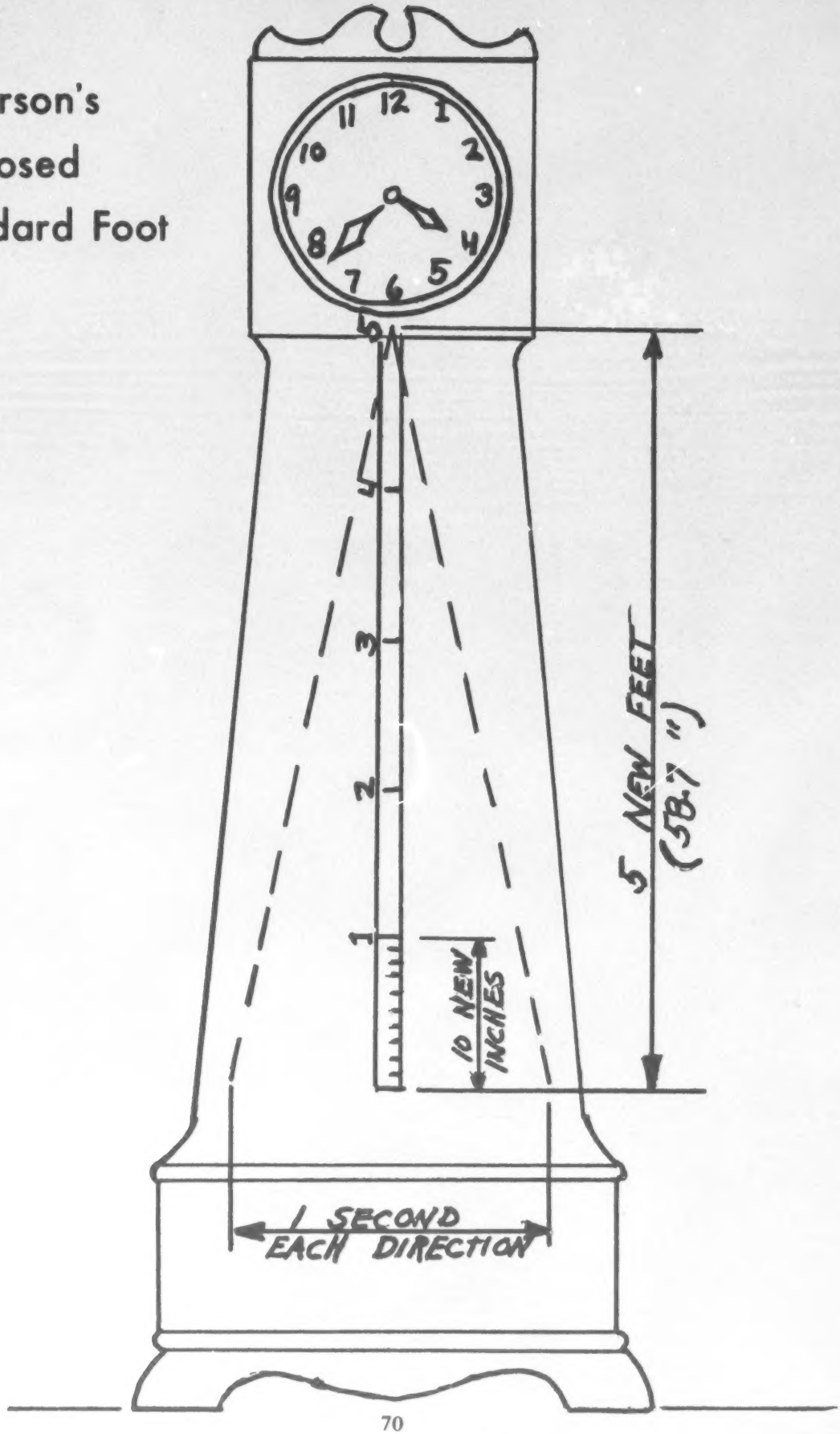
This Diagram Shows Relationship Between meter, gram, liter



(or 1 decimeter) each dimension
(or 1000 cubic centimeters)

ADDISON WESSLEY

Jefferson's
Proposed
Standard Foot



Comparing the Commonest Measurement Units

Approximate conversions from Customary to metric and vice versa.

	When you know:	You can find:	If you multiply by:
LENGTH	inches	millimeters	25
	feet	centimeters	30
	yards	meters	0.9
	miles	kilometers	1.6
	millimeters	inches	0.04
	centimeters	inches	0.4
	meters	yards	1.1
	kilometers	miles	0.6
AREA	square inches	square centimeters	6.5
	square feet	square meters	0.09
	square yards	square meters	0.8
	square miles	square kilometers	2.6
	acres	square hectometers (hectares)	0.4
	square centimeters	square inches	0.16
	square meters	square yards	1.2
	square kilometers	square miles	0.4
	square hectometers (hectares)	acres	2.5
MASS	ounces	grams	28
	pounds	kilograms	0.45
	short tons	megagrams (metric tons)	0.9
	grams	ounces	0.035
	kilograms	pounds	2.2
	megagrams (metric tons)	short tons	1.1
LIQUID VOLUME	ounces	milliliters	30
	pints	liters	0.47
	quarts	liters	0.95
	gallons	liters	3.8
	milliliters	ounces	0.034
	liters	pints	2.1
	liters	quarts	1.06
	liters	gallons	0.26
TEMPER-ATURE	degrees Fahrenheit	degrees Celsius	5/9 (after subtracting 32)
	degrees Celsius	degrees Fahrenheit	9/5 (then add 32)

WEIGHTS & MEASURES

TABLES OF UNITED STATES CUSTOMARY WEIGHTS AND MEASURES

(Definitions of Basic Units in Parentheses)

LINEAR MEASURE

12 inches	= 1 foot
3 feet	= 1 yard (0.9144 meter)
5½ yards	= 1 rod
40 rods	= 1 furlong = 220 yards
8 furlongs	= 1 statute mile = 1,760 yards
3 miles	= 1 league
5,280 feet	= 1 statute or land mile
6,076.11549 feet	= 1 International Nautical Mile (1852.0 meters)

SQUARE MEASURE

144 square inches	= 1 square foot
9 square feet	= 1 square yard
30¼ square yards	= 1 square rod
160 square rods	= 1 acre
640 acres	= 1 square mile

CUBIC MEASURE

1,728 cubic inches	= 1 cubic foot
27 cubic feet	= 1 cubic yard

LIQUID MEASURE

4 gills	= 1 pint
2 pints	= 1 quart
4 quarts	= 1 gallon (231.0 cubic inches)

DRY MEASURE

2 pints	= 1 quart
8 quarts	= 1 peck
4 pecks	= 1 bushel (2150.42 cubic inches)

ANGULAR AND CIRCULAR MEASURE

60 seconds	= 1 minute
60 minutes	= 1 degree
90 degrees	= 1 right angle
180 degrees	= 1 straight angle
360 degrees	= 1 circle

TROY WEIGHT

24 grains	= 1 pennyweight
20 pennyweights	= 1 ounce
12 ounces	= 1 pound, Troy

AVOIRDUPOIS WEIGHT

27 11/32 grains	= 1 dram
16 drams	= 1 ounce
16 ounces	= 1 pound (0.45359237 kilogram)
100 pounds	= 1 short hundredweight
20 short hundredwieghts	= 1 short ton

THE METRIC SYSTEM

LINEAR MEASURE

10 millimeters	= 1 centimeter
10 centimeters	= 1 decimeter
10 decimeters	= 1 meter
10 meters	= 1 dekameter
10 dekameters	= 1 hectometer
10 hectometers	= 1 kilometer

LIQUID MEASURE

10 milliliters	= 1 centiliter
10 centiliters	= 1 deciliter
10 deciliters	= 1 liter
10 liters	= 1 dekaliter
10 dekaliters	= 1 hectoliter
10 hectoliters	= 1 kiloliter

SQUARE MEASURE

100 sq. millimeters	= 1 sq. centimeter
100 sq. centimeters	= 1 sq. decimeter
100 sq. decimeters	= 1 sq. meter
100 sq. meters	= 1 sq. dekameter
100 sq. dekameters	= 1 sq. hectometer
100 sq. hectometers	= 1 sq. kilometer

WEIGHTS

10 milligrams	= 1 centigram
10 centigrams	= 1 decigram
10 decigrams	= 1 gram
10 grams	= 1 dekagram
10 dekagrams	= 1 hectogram
10 hectograms	= 1 kilogram
100 kilograms	= 1 quintal
10 quintals	= 1 ton

CUBIC MEASURE

1,000 cu. millimeters	= 1 cu. centimeter
1,000 cu. centimeters	= 1 cu. decimeter
1,000 cu. decimeters	= 1 cu. meter

Unit vs. Standard, A Clarification

The American College Dictionary states:

A **unit** is any specified amount of a quantity, as of length or volume, force, momentum, time, by comparison with which any other quantity of the same kind is measured or estimated.

A **standard** is the authorized exemplar of a unit of weight or measure.

Please Read On!

After reading the above definitions, it would seem there is little difference between a unit and a standard of measurement. If you wish to think of them as the same, no harm will be done to you or your students; However, here is an attempt to clarify (hopefully) or confuse you (unintentionally).

A **unit** is an arbitrarily agreed upon definition of some form of measure.

Eg. The liter is defined as 1 cubic decimeter or 1000 cubic centimeters

The gram is defined as the weight of 1 cubic centimeter of water at 39.2°F or 4°C at sea level.

A unit is independent of physical conditions even though it is defined in terms of the temperature, sea level, etc.

A **standard** is the physical embodiment of a unit and **is not** independent of physical conditions. It is the true embodiment only under the specified conditions.

Eg. A liter metal standard will have a capacity of one liter only when the standard is at a certain temperature.

A meter metal standard will have a length of one meter only when the standard is at a certain temperature supported in a certain way.

One further explanation: It may help to think of a unit as an arbitrarily agreed upon definition and a standard as a model built to fulfill the definition in every specified way.

Eg. Unit ⟶ gram = 1 cubic centimeter of water at 4°C at sea level

Standard ⟶ metal weight = the weight of one cubic centimeter of water at 4°C at sea level.

REFERENCES

A Metric America, A Decision Whose Time Has Come, National Bureau of Standards Special Publication, Catalog. No. C13, 10, 345, U. S. Government Printing Office, Washington, D. C. 20402

Education: U. S. Metric Study Interim Report, National Bureau of Standards Special Publication, Catalog No., C13, 10, 345-6, U. S. Government Printing Office, Washington, D. C. 20402

Addison - Wesley Math Series

D. C. Heath Science Series

Durst, Harold, et al., *High School Biology,* Rand, McNally and Company, Boulder, Colo. 1969 pp. 78-9

Periodicals

The Instructor
Grade Teacher
The Arithmetic Teacher
Science and Children
Weekly Reader
NEA Reporter
Boston Globe